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A CRITICAL REVIEW OF THE WORLD LITERATURE IN APPLIED MECHANICS
AND RELATED ENGINEERING SCIENCE

REVS. 2731-3082 VOL. 7, NO. 9 SEPTEMBER 1954

GENERAL

Theoretical and Experimental Methods. 379
Mechanics (Dynamics, Statics, Kinematics) 380

MECHANICS OF SOLIDS

Servomechanisms, Governors, Gyroscopics 381
Vibrations, Balancing 381
Wave Motion, Impact 382
Elasticity Theory 383
Experimental Stress Analysis 384
Rods, Beams, Shafts, Springs, Cables, etc. 386
Plates, Disks, Shells, Membranes 386
Buckling Problems 388
Joints and Joining Methods 388
Structures 389
Rheology (Plastic, Viscoplastic Flow) 392
Failure, Mechanics of Solid State 393
Material Test Techniques 394
Mechanical Properties of Specific Materials 395
Mechanics of Forming and Cutting 396

MECHANICS OF FLUIDS

Hydraulics; Cavitation; Transport 397
Incompressible Flow: Laminar; Viscous 398
Compressible Flow, Gas Dynamics 398
Turbulence, Boundary Layer, etc. 399
Aerodynamics of Flight; Wind Forces 401
Aeroelasticity (Flutter, Divergence, etc.) 402
Propellers, Fans, Turbines, Pumps, etc. 403
Flow and Flight Test Techniques 405

HEAT

Thermodynamics 406
Heat and Mass Transfer 408
Combustion 410

MISCELLANEOUS

Acoustics 413
Ballistics, Detonics (Explosions) 415
Soil Mechanics, Seepage 416
Micromeritics 417
Geophysics, Meteorology, Oceanography 418
Lubrication; Bearings; Wear 418
Marine Engineering Problems 420

Books Received, 378
Letters to the Editor, 378

Acoustic and Ultrasonic Relaxation Processes, E. G. Richardson, 377

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APPLIED MECHANICS REVIEWS

VOL. 7, NO. 9 MARTIN GOLAND *Editor* SEPTEMBER 1954

ACOUSTIC AND ULTRASONIC RELAXATION PROCESSES

E. G. RICHARDSON

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THE resuscitation of acoustics as a science in the past fifty years is largely due to military needs and the discovery of the means of producing ultrasonic energy. What is now called sonar was developed in World War I, copied as radar between the wars, and both used extensively for navigation and detection by echoes since. At the same time, one must not fail to mention developments in architectural acoustics, largely due to the energy of W. C. Sabine at Harvard, though space does not permit a discussion of these developments here.

Although ultrasonics has proved a convenient tool with which to irradiate materials in a beam of compressional energy, it should be noted that many of the applications are not specific to one small range of frequency but could equally well, though perhaps less conveniently, be done at lower frequencies. Such is not the case, however, with systems showing some form of resonance or antiresonance, and it is, in fact, such cases which it is proposed to study in this article.

Formerly, the velocity of sound in a gas was thought to be independent of frequency, the fact that the music of an open-air band is not distorted by distance being cited as proof. Soon after the discovery of ultrasonic quartz sources by P. Langevin, however, G.W. Pierce (1)[1] noted that at a frequency of about 100 kilocycles per second a notable rise of velocity occurred in carbon dioxide, accompanied by a considerable absorption of the energy. Following an idea which Debye had already pursued with success in explanation of the variation of dielectric constant with frequency, Herzfeld and Rice (2) suggested that this was an acoustic relaxation involving the transfer of translational into vibrational energy and taking time in the process. In other words, above a certain frequency there is not time for this transfer to take place and the molecules become effectively stiffer, hence, the rise in velocity of propagation and the change in phase between pressure and particle velocity which results in the attenuation of the ultrasonic signal as it passes through the gas.

In the succeeding twenty-five years similar relaxations have been discovered in other gases, though none so pronounced. The subject has received attention in recent years from workers in aerodynamics who are looking for vapors capable of being substituted for the air in supersonic wind tunnels. These should have a low velocity of sound in order that high Mach numbers may be reached without excessive tunnel speeds; but if their molecules can relax at lower frequencies than oxygen or nitrogen (which scarcely do so within yet attainable ultrasonic frequencies), then shock waves initiated in them may not properly reproduce conditions in the atmosphere. Possible vapors for this purpose are the freons and the hexafluorides, and work is going on in the author's laboratory on these vapors with aerodynamic applications in view.

In liquids, relaxations in the sense of anomalous absorption accompanied by a rise in velocity of propagation have not been definitely established since, within the limits of precision of present experimental technique, no dispersion of velocity with frequency has been established. This is not to say that the attenuation of the wave is normal in the sense that it is proportional to the kinematic viscosity of the liquid in the way that the "classical" formula of Stokes would have it be. In fact, although in many liquids the quotient absorption coefficient (frequency)^2 is a constant as it should be (and which precludes relaxation on the simple theory), this constant is in very few cases the Stokesian one; for instance, in benzene it is 600 and in carbon disulphide, 1000 times the expected value. It has been suggested by the author that this effect is connected with the ease of formation of cavitation nuclei in these liquids, which have high vapor pressures. Others ascribe it to a form of compressional viscosity, peculiar to the propagation of ultrasonic energy.

Before passing on to solids, it will be well to look a little further into the theory of relaxation.

The idea behind most of our present-day explanations of the behavior under stress of solid and quasisolid bodies stems from Maxwell who expressed the rate of strain of a substance in two terms, one proportional to and in phase with the stress, and one in phase with the rate of stress. In modern symbols

$$\dot{\sigma} = \frac{\dot{s}}{k} + \frac{s}{\eta} \qquad [1]$$

k being an elastic, and η a viscous coefficient. Such a material is known as viscoelastic. When there is merely a restoring force proportional to displacement, $\sigma = \frac{s}{k} + \text{constant}$, and the material is purely elastic: when the equation reduces to $s = \eta\dot{\sigma}$, it is purely viscous and the same will hold if the stress is kept constant during a plastic deformation.

If now a sinusoidal stress $s = s_o \exp i\omega t$ is applied to the viscoelastic substance, substitution in [1] yields

[1] Numbers in parentheses indicate References at end of paper.

$$\dot{\sigma} = s\left(\frac{1}{\eta} + \frac{i\omega}{k}\right) \qquad [2]$$

If we define the impedance of the system as $s/\dot{\sigma}$, this becomes

$$\left(\frac{1}{\eta} + \frac{i\omega}{k}\right)^{-1} \quad \text{or} \quad \frac{\eta(1 - i\omega\eta/k)}{1 + \omega^2\eta^2/k^2} \qquad [3]$$

when the real and imaginary parts of the complex viscosity coefficients are separated. We then write the real part of the viscosity as $\eta(1 + \omega^2\tau^2)^{-1}$ with the "relaxation time" (τ) in place of η/k.

Hand-in-hand with this goes an absorption of the oscillatory energy put into the body. The phase difference between stress and strain is an angle δ whose tangent is the ratio of the imaginary and real parts of the impedance. This difference of phase represents a loss of power and tan δ is, in fact, analogous to the power actor in alternating current technology.

This internal friction must be related to things which can be directly measured. These are (a) the decrement of amplitude of forced vibrations, and (b) the reciprocal width of a resonance peak under forced vibration.

In a number of materials available in the form of cylinders, torsional oscillations may be excited by clamping one end and attaching an iron inertia bar to the other which is then set in motion by external magnets. As the range of frequency of the experiments is raised, the investigator usually replaces flexural vibrations by torsional vibrations.

It is often more convenient to vary the temperature than the frequency. In general, the internal friction will fall as the temperature rises, but it rises in glass. If there is a relaxation peak in the infrasonic range, it will usually shift with temperature, so that at a given temperature the substance will have a loss which represents some point on the peak.

In some materials such as high polymers, important relaxation spectra are localized in the ultrasonic region and, in any case, no dynamical study of a solid is complete unless the whole gamut of available frequencies has been tried. This rules out the transverse vibration of strips, as they would be impossibly short to have ultrasonic resonance, but leaves both longitudinal and torsional waves as capable of excitation in rods at ultrasonic frequencies.

The usual apparatus for high-frequency measurements involves sticking a short cylindrical ultrasonic transducer by cement axially to the rod of material under investigation. Quimby (3) was the first to use this method for velocity, and more recently Marx and Sibbertson (4), using a quartz cylinder, in this way sent longitudinal waves along glass rods contained in furnaces for varying the temperature.

In metals, a pronounced effect occurs due to scattering of the radiation by crystallites which are embedded in the more or less amorphous matrix. At low frequencies the Rayleigh (optical) law of scattering for particles small compared to the wave length is followed whereby the energy scattered is proportional to $\bar{v}^2/\lambda^4$, v being the volume of a grain. As the frequency is raised and the wave length (λ) in the metal approaches the grain diameter (d), we enter the difficult region known in optics by the name of Mie, where the scattering rises to a maximum.

Mason and McSkimin (5) have shown experimentally that in this critical region the scattering follows an f rather than f^4 law. This is probably an approximation to the theoretical form of the scattering curve near $\pi d/\lambda = 1$. The scattering rises then nearly linearly with f.

The analysis of these relaxation spectra is still a matter of difficulty unless the peaks are quite distinct. If a number of peaks appear separate with "cols" between them, it is still possible to write the function which represents the spectrum as a Fourier series or Laplace transform and, by differentiating the curve of real part of the complex modulus against log frequency, derive approximately the coefficients and locations of terms in the series; but if many peaks are superposed, the process is tedious or impossible.

Finally, one must look for possible causes of relaxation. In metals these are many but lie in characteristic parts of the frequency scale. Reference must be made to Zener's book (6) for a discussion of these points. In glass and polymers the possible causes of relaxation processes may be fewer but this does not make the suspected relaxations any easier to disentangle.

REFERENCES

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3 Quimby, S. L., *Phys. Rev.* **25,** p. 558, 1925.
4 Marx, S. W., and Sibbertson, J. M., *J. appl. Phys.* **24**, p. 84, 1953.
5 Mason, W. P., and McSkimin, H. J., *J. acoust. Soc. Amer.* 19, p. 46, 1947.
6 Zener, C. M., Elasticity and anelasticity of metals, AMR 3, Rev. 1104.

Books Received for Review

BERANEK, L. L., Acoustics, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1954, x + 481 pp. $9.

COX, G. N., and PLUMTREE, W. G., Engineering mechanics, 2nd ed., Toronto, New York, London, D. Van Nostrand Co., Inc., 1954, ix + 382 pp. $5.50.

DUDLEY, D. W., Practical gear design, New York, Toronto, London, McGraw-Hill Book Co., Inc., 1954, x + 335 pp. $7.

GIRKMANN, K., Flächentragwerke, 3rd rev. ed., Wien, Springer-Verlag, 1954, xvii + 558 pp., 308 figs. $15.80.

KERSTEN, C., Brücken in Stahlbeton. Bd. I. Platten- und Balkenbrücken, 8th ed. (revised by Dedering, C.), Berlin, Wilhelm Ernst & Sohn, 1953, viii + 224 pp. DM 19.

LEWENSON, L. B., Kinematik und Dynamik der Getriebe, Berlin, Verlag Technik, 1952, 421 pp., 276 figs. DM 22.

MÖLL, H., Spannbeton, Stuttgart, Berliner Union, 1954, 222 pp., 271 figs. DM 48.

SCHMIDT, E., Einführung in die Technische Thermodynamik und in die Grundlagen der chemischen Thermodynamik, 5th ed., Berlin, Springer-Verlag, 1953, xvi + 520 pp., 244 figs., 69 tables. DM 30.

TRUESDELL, C., The kinematics of vorticity, Bloomington, Indiana University Press, 1954, xvii + 232 pp. $6.

WINTER, F. W., Technische Wärmelehre. Grundlagen und ausgewahlte Anwendungen für Studium und Praxis, Essen, Verlag W. Girardet, 1954, 312 pp., 240 figs. DM 19.80.

Letters to the Editor

2731. Re AMR 7, Rev. 998 (April 1954): D. M. Éĭdus. Estimate of the modulus of eigenfunctions (in Russian).

In line 5, equation should read $k = [m/4] + 1$, rather than $k = (m/4) + 1$. In line 8, equation should read $k = (m - 1)/4$, rather than $k = (M - 1)/4$.

The editors regret these typographical errors.

2732. Concerning AMR 7, Rev. 1409 (May 1954): H.

Deresiewicz, **Contact of elastic spheres under an oscillating torsional couple.**

Reviewer regrets having stated that author erroneously credits a solution, due to Reissner and Sagoci, to R. D. Mindlin. Closer examination of the author's paper convinces reviewer that author's crediting is correct. J. L. Lubkin, USA

2733. **Re AMR 7, Rev. 1796 (June 1954): K. E. Knudsen, C. H. Yang, B. G. Johnston, and L. S. Beedle, with appendix by W. H. Weiskopf, Plastic strength and deflections of continuous beams.**

The editors regret that the name of L. S. Beedle was omitted as one of the authors in our listing of the above paper.

Theoretical and Experimental Methods

(See also **Revs. 2742, 2748, 2762, 2767, 2783, 2798, 2820, 2828, 2829, 2885, 2907, 2915, 2918, 2936, 3003**)

2734. **Focken, C. M., Dimensional methods and their application,** New York, St. Martin's Press; London, Edward Arnold & Co., 1954, viii + 224 pp. $6.

About half of this book is devoted to the philosophy of physical quantities, magnitudes, units, dimensions, and systems of measurement. Author states that his views in these matters have been influenced strongly by the writings of P. W. Bridgman and H. Dingle. The arguments that are offered are designed to convince the reader by an appeal to his physical intuition and common sense, rather than by mathematical logic. Author does not undertake to place the subject on a postulational basis, nor to fit his philosophy into the framework of modern algebra. There is no mention of the group theoretic aspects of the subject, which lead to useful generalizations, as shown by Garrett Birkhoff in his "Hydrodynamics."

The latter half of the book is devoted primarily to illustrative applications of dimensional analysis. Many of the examples are taken from the general fields of electronics and electromagnetic theory. Illustrations in the fields of hydraulics, gas dynamics, heat transfer, and stress analysis are confined principally to the last chapter. This chapter also contains a discussion of model testing and model laws from the point of view of dimensional analysis. The derivation of model laws by means of the differential equations that govern particular phenomena is not discussed. Some interesting and novel applications of dimensional analysis and model testing in studies of geological phenomena and chemical plant operations are described.

Numerous references to papers and books on dimensional analysis are provided. Some problems to be solved by students are presented.

Some specialists in dimensional analysis will appreciate the emphasis that this book places on the philosophic foundations of the subject, since the confusion in this domain is seemingly becoming more acute, particularly in connection with the units of electrical and magnetic quantities. Also, those who are interested in applications of dimensional analysis to problems of electromagnetic theory will find much useful information in the work.

H. L. Langhaar, USA

2735. **Bieberbach, L., Theory of ordinary differential equations [Theorie der gewöhnlichen Differentialgleichungen],** Berlin, Springer-Verlag, 1953, ix + 338 pp. DM 36.

Author assumes the reader knows theory of functions of a complex variable, and the book is devoted to relating the analytic character of the differential equation to the analytic character of the solution. Hence, title of book is misleading and should have been "Differential equations in the complex domain."

After proving the standard existence theorems, the author carefully examines the types of singularities which may occur in differential equations, and he illustrates by numerous examples the effect these singularities may be expected to have on the solutions. Solutions of $dw/dz = (aw + bz)/(cw + dz)$ are studied in detail, and related to those of $dw/dz = f(z, w)$. Other topics considered include equations of Fuchsian type, the hypergeometric and Bessel differential equations, and those with periodic coefficients.

Despite author's experience as a textbook writer, he still gives references to the literature in a scanty and slipshod manner, sometimes giving only the name of the man, and occasionally the journal and year, but never a complete reference. This decreases considerably the value of the text. A. W. Goodman, USA

2736. **Simultaneous linear equations and the determinations of eigenvalues,** U. S. Dept. Comm., Nat. Bur. Standards, *Appl. Math. Ser.* **29,** 126 pp., Aug. 1953. $1.50.

Volume is proceedings of a symposium held in 1951 and contains 19 articles dealing with various aspects of subject in title. Space does not permit survey of each paper, but brief statements of some selected ones should be indicative of book's excellent coverage and usefulness. For example, the first article, "Tentative classification of methods and bibliography on solving systems of linear equations" by G. E. Forsythe, lists some 450 references. The outline of methods and bibliography are cross-indexed to each other. In this connection, a shorter but more selected bibliography of 133 titles is available in "Solving linear equations can be interesting," same author, *Bull. Amer. math. Soc.* **59,** 299–329, July 1953. An analysis of various types of errors occurring in matrix computations is the subject of an article by P. S. Dwyer [see also AMR **4,** Rev. 4055]. In an expository paper, J. B. Rosser summarizes results of research conducted at Institute of Numerical Analysis (INA), National Bureau of Standards, dealing with the solution of linear sets of equations. In another paper, M. R. Hestenes describes work of INA concerning determination of eigenvalues and eigenvectors of matrixes. R. A. Frazer discusses some problems in aerodynamics and structures related to eigenvalues. Y. Luke, USA

2737. **Cohn, G. I., and Saltzberg, B., Solution of nonlinear differential equations by the reversion method through the first thirteen terms,** *J. appl. Phys.* **25,** 2, 252–254, Feb. 1954.

In a previous paper [AMR **6,** Rev. 2670], authors have shown that certain types of nonlinear differential equations can be reduced to a set of ordinary linear differential equations. This is called reduced set. There the 14th and 15th equations of reduced set were tabulated. Here the first 13 are tabulated.

Y. Luke, USA

2738. **Kestin, J., and Zaremba, S. K., Geometrical methods in the analysis of ordinary differential equations,** *Appl. sci. Res.* (*B*) **3,** 3, 149–189, 1953.

Paper carries a subtitle, "Introduction to nonlinear mechanics." Although this subtitle contains too sweeping a claim, the paper presents a very clear exposition of the use of the phase plane for dealing with nonlinear problems, in one degree of freedom. It discusses not only the "simple" singular points, as most treatises do, but includes also a number of important remarks on singular points of higher order. Furthermore, some comments are given on the asymptotic behavior of the integral curves. Next, the Kronecker index is discussed; here attention is drawn to the different definitions used by Kronecker and Poincaré, a difference which occasionally caused some confusion in the literature.

In textbook fashion, examples are provided to illustrate many of the points in debate. K. Klotter, USA

2739. **Blanch, Gertrude, On modified divided differences I,** *Math. Tables Aids Comput.* **7,** 45, 1–11, Jan. 1954.

Application of divided differences in numerical work is somewhat limited. Their construction requires division, sometimes by small numbers. They do not lend to easy interpretation as ordinary differences in that checking of a table and determination of meaningful significant figures in successive differences is of considerable difficulty. Paper shows how divided differences can be modified so that they resemble many characteristics of ordinary differences. Author proves theorem relating to error magnification and location of isolated and multiple errors in base entries which are considerably larger than errors of other entries in region of consideration. Several numerical examples are presented. Errors due to rounding approximate entries to a fixed number of decimals, and errors of a smaller nature than those above will be subject of part II of paper. Y. Luke, USA

2740. **von Gorup, G., Calculation of stream function at a boundary which has edges** (in German), *ZAMM* **33,** 8/9, 304–305, Aug./Sept. 1953.

This is a continuation of author's work [AMR **6,** Rev. 3114] concerning the calculation of the stream function in the region outside of a time variable contour. Here he considers the case when the contour has an edge. Thus the mapping function should have a ramification and is not meromorphic. Using a function mapping a special contour with right angle, author shows how the stream function can be obtained. The generalization to the case of any contour with right angle consists in multiplying this mapping function by an appropriate factor which is meromorphic and is regular outside the contour. J. Beránek, Czechoslovakia

2741. **Chantal, R., Utilization of curves of equal density and probability for quasi-certain location of an airplane** (in French), *Ann. Ponts Chauss.* **123,** 5, 583–608, Sept.-Oct. 1953.

Purpose is to show how the theory of probability can be used in radiogonometry, as well as with radar, to ascertain the position of an airplane in space to a quasi-certitude. It is shown that any airplane, although only approach coordinates are available, can be found, as precisely as desired, inside a curve of equal density of probability. These curves, which are plotted beforehand, immediately provide the zone of uncertainty where the plane happens to be. From author's summary

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 2738, 2789, 3046)

2742. **Pletta, D. H., Engineering statics and dynamics,** New York, The Ronald Press Co., 1951, ix + 392 pp. $5.50.

Book is an undergraduate-level text in statics and dynamics with emphasis on the solution of practical problems through the use of a minimum number of fundamental concepts. The six chapters on statics cover the usual topics, plus the noteworthy addition of a chapter on "Internal resistance of solid bodies," including shear and moment diagrams for beams, relation between V and M, and equations of the V and M curves; however, the load-shear relations are not stressed. The fact that the equations of statics alone may be insufficient to permit solution of certain problems is repeatedly brought before the student. Graphical and analytical solutions are carried simultaneously where possible. Some 400 statics problems, with answers to the odd numbered and with one or more examples for each type problem, are given. Eight chapters on dynamics (350 problems with answers to the odd numbered and with adequate examples) include chapters on vibrations of single-degree-of-freedom systems and on dimensional analysis and model similarity. The appendix summarizes the essential principles of statics and dynamics. A good book for civil and mechanical engineers and for extension courses in mechanics. J. W. Turnbow, USA

2743. **Geronimus, Ya. L., On the mass of a body reduced to the line of impact** (in Russian), *Prikl. Mat. Mekh.* **17,** 5, 631–633, Sept.-Oct. 1953.

The author proves first that the angular velocity imparted to a resting rigid body by a single-force blow along a line AB and of a torque M_c about the mass center C has the component M_c/Mp^2 normal to ABC (M is mass of body; p radius of the central ellipsoid of gyration normal to ABC). A complete determination of this velocity is given in Ex. 4, art. 310, of Routh's "Elementary rigid dynamics," Macmillan [1905]. Since M, p are only two numbers, it is clear that the particle-velocity projections onto ABC can be duplicated if the body is reduced to two rigidly connected particles. If one of them, P, is at B, ABC being a right angle, this reduction is clearly unique. The velocity acquired by P will be clearly the same as if it had been free. Its mass, by Joukowsky's definition, is the "body mass reduced to the line of blow."

There is considerable lost motion in this short paper.

A. W. Wundheiler, USA

2744. **Bereis, R., Two-dimensional symmetrical rolling** (in German), *Öst. Ing.-Arch.* **7,** 3, 243–246, 1953.

A rolling is called symmetrical if a plane curve rolls on a congruent curve always symmetrically located in respect to the common tangent. The trajectory of a moving point can be found by reflecting a fixed point in the tangents of the fixed curve. Author studies the differential-geometrical properties of the motion up to the fourth degree by approximating it by the rolling of the two equal oscillating circles, the two oscillating parabolas, etc., and, as these motions are well known, they give rise to simple and elegant theorems on symmetrical rolling. For instance, the Burmester points are the foci of the conic which has a five-point contact with a moving curve in the instantaneous center.

O. Bottema, Holland

2745. **Kazakevich, N. L., High-speed power transmissions employing reduction gears [Moshchnïe skorostnïe zubchatïe peredachi],** Moscow, Gosud. Nauch.-Tekh. Izdat. Mashinostroit. Lit., 1950, 208 pp.

Large-size gear transmissions for high-speed application such as are used between the turbines and propellers of a surface vessel, or reduction of speed from a turbine to the generator in a stationary power plant are discussed in this volume, emphasizing general methods of design, ways of assembly, and maintenance.

This book is not a text for the design engineer but will appeal to the master mechanic or technician, since only the minimum of mathematics is used and no analysis for the methods employed in a particular design is given. Through the whole treatise the keynote is, "that is how it's done."

Useful information pertaining to the detail design of gears, shafts, thrust, and running bearings are given, but there is no discussion as to the different gear systems used. A whole chapter is devoted to gear checking, in which most of the classical methods such as "diameter over pins," special gear calipers, and other ways are explained. No mention is made of modern optical and mechanical test apparatus, such as the Kodak Conju-Gauge. No reference to surface finish, as we express it, is made, but half a

chapter is devoted to methods and tools explaining the hand scraping. Measurements and fixtures used in checking concentricity are also discussed.

A chapter is devoted to lubrication, with formulas of greases for different types of services.

Dynamic balancing of the individual parts is explained in the "how-to-do-it" style with no reference to the theoretical background governing such procedures nor to the design and use of balancing machines. This fact is particularly strange as the early theories of dynamic-balancing test apparatus originated with Russian nationals (Timoshenko, Akhimoff, Minorsky, and others).

In most instances the author is careful to show the different technical solutions for large, medium, and restricted volume production, a feature well worth while and particularly well done.

References to foreign or Russian publications are very few and completely inadequate if this book is to fulfill its purpose and serve as an introduction to this vast subject.

The line drawings are hard to read owing to poor reproduction, and the photographs are way below our standards. A translation of this book is not recommended as it does not contain new or unavailable material. S. J. Zand, USA

2746. **Ehricke, K. A., Take-off from satellite orbits,** *J. Amer. Rocket Soc.* **23,** 6, p. 372, Nov.-Dec. 1953.

Servomechanisms, Governors, Gyroscopics

(See also Rev. 2763)

2747. **Pélegrin, M. J., Statistical calculation of servomechanisms** (in French), *Publ. sci. tech. Min. Air. Paris* no. 285, 156 pp., 1953.

This is a good review of servomechanism theory with special application to automatic pilots and with some good side remarks on ways of handling the transient effects of relays and atmospheric turbulence. The treatment is properly mathematical in nature and the article is well supplied with illustrations and examples. W. C. Johnson, Jr., USA

2748. **Yeh, V. C. M., The study of transients in linear feedback system by conformal mapping and the root-locus method,** *Trans. ASME* **76,** 3, 349–359, Apr. 1954.

If the inverse of the open-loop transfer function for a servomechanism is expressed in terms of the complex variable, a system of orthogonal curves or a conformal map is obtained. The root locus is a special angle locus whose phase angle is an integral multiple of π. Odd integral multiples of π denote degenerative feedback, even regenerative feedback. The gain of the open-loop transfer function determines the position of the poles of the closed-loop transfer function, and these poles lie on the root locus.

The paper gives a method of finding analytical expressions for the root loci and discusses the manner in which the shifting and reshaping of the root locus by controller adjustments is possible.

Root locus equations for systems having up to four open-loop roots are tabulated in the paper.

Reviewer feels that the paper represents an advance in the tools available for the study of closed-loop systems.

W. A. Wolfe, Canada

2749. **Sternberg, R. L., and Kaufman, H., A general solution of the two-frequency modulation product problem,** *J. Math. Phys.* **32,** 4, 233–242, Jan. 1954.

Paper presents a general method for readily obtaining approximate numerical values of the amplitudes of the modulation products which occur in the output when a two-frequency input is applied to an arbitrary modulator having a continuous output versus input characteristic; a partial analytical solution of the problem is also indicated. From authors' summary

2750. **Boerdijk, A. H., Mechanical generators** (in Dutch), *Ingenieur* **66,** 4, 1–5, Jan. 1954.

Author discusses first the operation of a mechanical amplifier consisting of two drums, one of which is driven by a motor and the other of which is free. Ropes or belts, which can be made to grab or which can be loosened by the rotation given to an input shaft, are around the two drums. This amplifier amplifies torque at constant speed. Next, a simple torsional vibration system is attached to the input shaft of the amplifier, and the output shaft through gears is made to feed back to the torsional flywheel through friction. This system is self-oscillating. Several examples of mechanical feedback are shown and a brief discussion is given of the effects of nonlinearity.

J. P. Den Hartog, USA

2751. **Hollander, L., Application of the three-way control valve,** *Instrum. Automat.* **27,** 3, 454–456, Mar. 1954.

Three-way control valves permit simplification of many temperature-control problems involving by-pass flow. Proper sizing of the three-way valve can be accomplished by comparison of flow-lift characteristics of two-way and three-way valves, using the proved techniques for the former in sizing the latter.

From author's summary

2752. **Dennis, N. G., Water turbine governors,** *Instn. mech. Engrs. Proc.* **1B,** 9, 379–390, 1952–1953.

General description of some well-known principles and devices related to title subject. L. S. Dzung, Switzerland

Vibrations, Balancing

(See also Revs. 2738, 2742, 2750, 2967, 3057)

2753. **Penzien, J., and Hansen, R. J., Static and dynamic elastic behavior of reinforced concrete beams,** *J. Amer. Concr. Inst.* **25,** 7, 545–567, Mar. 1954.

Static and dynamic tests show reasonable correlation with theory if allowance is made for creep, cracking, and damping in the concrete. Conventional straight-line theory is applicable to static tests provided that compressive reinforcement is used. Beams were first loaded statically to remove creep and to prevent additional cracking in dynamic tests. Beams without compressive reinforcement showed considerable variation in dynamic load factor along beam length, this being attributed to shifting of neutral axis during vibration. This variation disappeared for beams with compressive steel. Experimental damping coefficient varied between 6 and 8% of critical damping.

Authors recommend that beams be underreinforced so that failure occurs in steel rather than in the more unpredictable concrete. Increase of steel yield stress and dynamic loading factor should be considered in design.

Noteworthy feature of paper is detailed theoretical analysis for dynamic loading of uniform simple span beam.

R. B. McCalley, Jr., USA

2754. **Bishop, R. E. D., The normal functions of beam vibration in series solutions of static problems,** *J. roy. aero. Soc.* **57,** 512, 527–529, Aug. 1953.

2755. Stüssi, F., Beam vibrations due to a moving load (in German), *Publ. int. Assn. Bridge struct. Engng.* **13,** 339–355, 1953.

Author develops method for finding a single-degree-of-freedom system equivalent to motion of a point on a beam subject to moving load. It is assumed that first mode only is important in obtaining constants of equivalent system. Resulting differential equation is solved numerically for three different velocities of traveling load and compared with results obtained experimentally. Agreement is good except for a time lag in the measured displacement-time curves between response and arrival of moving load. H. J. Plass, Jr., USA

2756. Masur, E. F., On the fundamental frequencies of vibration of rigid frames, Proc. First Midwestern Conf. Solid Mech., Engng. Exp. Sta., Univ. of Ill., 89–94, Apr. 1953.

Lower and upper bounds to the fundamental frequency of vibration of continuous structures are established from the convergence or divergence of a modified moment-distribution process. The method is extended to structures admitting sidesway, and the results are compared with those of an approximate method, which replaces the actual structure with one having only a finite number of degrees of freedom.

From author's summary by G. Herrmann, USA

2757. Wilson, T. S., The calculation of whirling speeds of a system of rotors keyed to co-axial shafts, *Aero. Res. Counc. Lond. Rep. Mem.* no. 2709, 24 pp., May 1948, published 1953.

Author applies iterative technique of Duncan and Collar to systems with lumped inertias. Method is extended to yield two modes during the same computation when the iteration converges slowly. Influence coefficients are listed for various configurations and a number of numerical examples, including a contrarotating propeller system, are given.

A. I. Bellin, USA

2758. Sykes, A. O., A study of compression noise isolation mounts constructed from cylindrical samples of various natural and synthetic rubber materials, *David W. Taylor Mod. Basin Rep.* 845, 55 pp., Oct. 1953.

Transmissibility data are presented for a number of idealized compression mounts constructed from various types of rubber, including Hevea (natural rubber), Hy-car OR-15, GR-S, GR-I-25, Neoprene FR, sponge rubber, a foamed rubberlike polyvinyl chloride, a material composed of rubber-bonded cork particles, and a high damping rubberlike ethoxyline plastic. The theory of AMR **5,** Rev. 1641 and AMR **4,** Rev. 4386 is extended to high damping materials.

From author's summary by R. Plunkett, USA

Wave Motion, Impact

(See also Revs. 2753, 2758, 2975, 3040, 3045)

2759. Symonds, P. S., and Leth, C. F. A., Impact of finite beams of ductile metal, *J. Mech. Phys. Solids* **2,** 2, 92–102, Jan. 1954.

Problem considered is the deformation of a uniform beam moving transversely to its length subsequent to the impact of its midpoint on a fixed stop. Various durations of application of the constraint are treated. The material of the beam is plastic-rigid nonhardening. Deformation is assumed to occur by formation of plastic hinges located at the midpoint and at two positions symmetrical about it and varying with time. These latter hinges travel away from the center until the angular velocity of the inner and outer segments is equal. It is stated that the bar then deforms by rotation about the central hinge alone. Diagrams indicate the configurations for various times of impact. Paper concludes with a discussion of the assumptions made and how physical considerations modify the results.

J. F. W. Bishop, Scotland

2760. Kane, T. R., Reflection of flexural waves at the edge of a plate, ASME Ann. Meet., New York, Dec. 1953, Pap. 53—A-42, 8 pp.

Mindlin's equations of flexural motion of plates are used to study the reflection of a straight-crested wave at the edge of a semi-infinite plate. The equations accommodate three modes of motion: two types of flexural waves and a thickness-shear wave. It is found that, in general, all three of these motions are excited upon incidence of any one of them at a free edge. The shear motion, here encountered, is of particular interest; for this motion is absent in the classical theory of plates, whence the applicability of that theory is restricted to a range of frequencies considerably below that corresponding to the first mode of thickness-shear vibration. By the same token, the present theory does not include the higher modes of motion which are to be found in three-dimensional elasticity theory; thus the solution set forth in the paper may be expected to furnish an adequate description for frequencies which do not materially exceed that of the first thickness-shear mode.

From author's summary by N. O. Myklestad, USA

2761. Junger, M. C., The concept of radiation scattering and its application to reinforced cylindrical shells, *J. acoust. Soc. Amer.* **25,** 5, 899–903, Sept. 1953.

Paper presents an approach which permits the analysis of elastic scatterers embodying complicated structural characteristics. Such problems cannot be investigated by means of the methods previously applied to the study of the scattering action of simple elastic bodies.

The scattered wave pressure produced by elastic scatterers may be expressed as the sum of two terms, one representing "rigid body scattering," i.e., the scattering which would exist if the scatterer were rigid, and the other representing "radiation scattering," which is associated with the sound radiated by the scatterer vibrating under the effect of the incident wave pressure. These two terms are derived here for three important cases.

The problem is now reduced to one in elasticity, specifically to the problem of solving the equations of motion of the elastic system for its forced response. The scattering pattern can then be computed. This procedure is applied to a scatter in the form of a cylindrical shell reinforced with regularly spaced septa.

From author's summary

2762. Landecker, K., On a property of a family of equiangular spirals and its application to some problems of wave propagation, *J. appl. Phys.* **25,** 1, 41–48, Jan. 1954.

Paper deals with a simple geometrical theorem of equiangular spirals, which reduces mathematical work when solving problems concerned with standing wave pattern and wave propagation in attenuating transmission lines. It is shown that both voltage and current vectors can be represented in a diagram using two symmetrical equiangular spirals. Peak values of voltage and current are given by means of a simple construction based on the theorem. Solutions of practical examples as to voltage, current, phase distribution, and interference of waves in an attenuating medium are introduced. Attention is paid to special case without attenuation when both spirals degenerate into one circle, which can be transformed by inversion (reciprocal radii) to Smith and Kenelly chart.

Paper is a very useful contribution for solving electric transmission lines. The results obtained can be transferred to analogous problems of acoustic wave guides.

V. Kopřiva, Czechoslovakia

2763. **Stoker, J. J., Unsteady waves on a running stream,** *Comm. pure appl. Math.* **6,** 4, 471–481, Nov. 1953.

A pressure disturbance is applied at time $t = 0$ to the surface of a stream flowing with uniform velocity U over a horizontal bed (depth h). The character of the motion changes radically when the Froude number $F = U^2/gh$ passes through the critical value unity. As $t \to \infty$ the wave amplitude dies out both upstream and downstream if $F > 1$, and it dies out upstream but not, in general, downstream if $F < 1$. Author fails to point out that this represents the well-known phenomenon of a wake behind a moving vessel. It is shown clearly that the solution of this initial value problem for $t \to \infty$ avoids the difficulties in the steady-state treatment of Rayleigh and Lamb of having to resort to rather arbitrary frictional forces or a radiation condition at ∞.

W. H. Munk, USA

Elasticity Theory

(See also Revs. 2742, 2788, 2793, 2795, 2799, 2809, 2820, 2834, 2836, 2837, 2849, 2855, 2875, 2877)

2764. **Roark, R. J., Formulas for stress and strain, 3rd ed.,** New York, McGraw-Hill Book Co., Inc., 1954, xiv + 381 pp. $7.50.

The third edition of this well-known book presents additional material on beams (shear lag, circular arches), on flat plates (coefficients of edge slope, rectangular plates with large deflection), on columns, on pressure vessels, and on stress concentration (Neuber factors). Carefully selected references have been added to bring the status of each subject up to date from the standpoint of design interest.

R. E. Peterson, USA

2765. **Cox, H. L., Four studies in the theory of stress concentration,** *Aero. Res. Counc. Lond. Rep. Mem.* 2704, 58 pp., Jan. 1950, published 1953.

First study, entitled "The effect of holes on the strength of materials under complex stress systems," considers biaxial loadings and circular and elliptical holes. Since at the periphery of the hole only one principal stress is not zero, failure is independent of the criterion of strength unless the material is not equally strong in tension and compression. Limiting curves for various ratios of shear to uniaxial stress are given and compared with fatigue test data. The possibility that material flaws affect strength like cylindrical cavities is investigated with negative results.

Part II is entitled, "Stress concentration due to holes and grooves other than elliptical in form." Polygonal forms with flat, rounded, and re-entrant sides, ellipses, and squares with rounded corners are investigated. Two practicable methods for successively approximating to a given form of hole by using an epicyclic conformal transformation are described. Stress concentrations due to uniform shear parallel to the axis of a hole and to biaxial stresses perpendicular to it are studied. It is demonstrated that abrupt changes of curvature of the contour of a hole or groove cause no concentration of stress. The effect of hairline cracks in masking stress concentrations is examined, and the necessary crack depth to explain the discrepancy between theoretical and experimental results is found so great that the cracks should be easily observable under the microscope. No such flaws have been observed.

Part III is entitled, "The effect of surface irregularities on fatigue strength." Stress concentrations due to a continuous surface undulation approximating a sine wave are found and the results applied to ground, honed, and shot-peened finishes.

Part IV, entitled "Stress concentration in twisted shafts," has for its purpose ". . . to demonstrate that the solution of the torsion problem for any arbitrary section depends solely upon the specification of an appropriate system of co-ordinates," the remainder of the work being "straightforward computation." Factors for polygonal shafts are found, also for a round shaft with a flat and for splined shafts.

The four papers were written between 1937 and 1947 in connection with experimental work at the National Physical Laboratory (England), and combine mathematical theory with a commendable awareness of practical physical problems.

A. D. Topping, USA

2766. **Jung, H., Contribution to nonlinear elasticity theory** (in German), *Ing.-Arch.* **21,** 3, 194–207, 1953.

Author uses Eulerian finite strain components with quadratic terms. He uses stress-strain law formulated by Roš and Eichinger for work-hardening materials, and assumes that this law is formally the same as Hooke's law except that the two constants are now replaced by two functions of invariants of the strain tensor. These functions are expressed as power series, and second-order theory is obtained by keeping one nonconstant term in each series. Displacement solutions are obtained for some elementary uniform stress states. Torsion, plane strain, and plate bending are discussed, but no exact second-order solutions are obtained for these problems.

L. Malvern, USA

2767. **Wilhoit, J. C., Jr., An addition to Poritsky's solutions of a differential equation of torsion,** *Quart. appl. Math.* **11,** 4, 499–501, Jan. 1954.

To the product solutions given by Poritsky [AMR **4,** Rev. 1957], author adds some additional solutions for the torsion of circular shafts of variable cross section. These are solutions for the stress function ψ, useful in the analysis of the cone and sphere, in which the variation with the radius R in spherical coordinates is of the first power. Also developed are two logarithmic solutions which have derivatives varying as R^{-1}; these are useful in the analysis of the cone with stress surface.

J. E. Duberg, USA

2768. **Duncan, W. J., The flexural centre or centre of shear,** *J. roy. aero. Soc.* **57,** 513, 594–597, Sept. 1953.

Paper reviews work on the flexural center of elastic cantilever beams and contains a number of hitherto unpublished results, including a formula giving the position of the flexural center in terms of the Prandtl torsional stress function.

From author's summary

2769. **Hoadley, A., Simple models help students to visualize Maxwell's theorem of reciprocal deflections,** *Civ. Engng., N. Y.* **24,** 1, 63–64, Jan. 1954.

2770. **Burzyński, W., On deficiencies and necessary supplements to the Saint Venant theory of straight bars** (in Polish), Prace Wrocławskiego Towarzystwo Naukowego, Wrocław, (B) no. 42, 75 pp., Dom Książki, 1951.

Author considers fundamental cases of straight bar. Classical solution of these cases, given by Saint Venant, is accurate mathematically, nevertheless it has serious deficiencies in its applications. Classical solution leads to determination of the function

of "meandering" and the two functions of displacement. Boundary conditions of the latter two are much more simply presented by the author than by Saint Venant. Author has pointed out thus far unknown details; for instance, he proves that, in the case of twisting in classical solution, the axis of "meandering" always passes through an immovable point of fixed section, so its position cannot be, as it is maintained, dependent on the shape of section. In a case of nonuniform bending, the solution requires all three functions to be known. This detail, and with some confusion of terminology, has led to misunderstandings in the literature. Some have supposed torque (twisting moment) to exist in a bent bar, because of identifying geometrical twist (which is named "meandering" by the author) with mechanical twist or replacing the geometrical center of sections by the center of shear.

Most valuable contribution in this work is determination of coordinates of the latter points (center of shear) by the function of meandering only. Until now it has been accepted that these coordinates can be determined only by the two known functions of displacement.

This deficiency of the classical solution, and lack of another equally accurate one respecting the real support conditions, compelled the author to work out a sufficiently accurate solution. It is known that there is a possibility of an energy solution, but in the literature there is no explanation of the difference between the two solutions. It results from a lack of determination of the elastic energy of the system, taking into account all influences, and from the fact that the well-known form of Castigliano's principle is only an abbreviation of a more extensive minimal theorem in which there is silently admitted the fixing of the sections, not in one point—as in classical solution—but in the whole area of the section.

When support conditions in both solutions are different, there must be also a difference in the two solutions. The starting point of Burzyński's solution is the correct assumption that elastic energy of a sufficiently long bar, even in changed support conditions, is practically equal to elastic energy calculated for classical solution. Here the author is guided by the principle of declining of effect due to differences in vectorially equivalent force collections. Elastic energy computed in this way includes, besides squares of forces and moments, also mixed products of torque (twisting moment) and both shearing forces. Applying Castigliano's principle, author has found generalized displacements. Solution found by the author has some peculiar characteristics. There exists—unlike in the classical solution—a natural axis of meandering. Center of meandering covers the center of shearing. Some added expressions of this solution are consistent with those of classical solution. Remaining expressions may agree in both solutions in spite of their different meaning. Classical solution may be applied henceforth, provided that too rigid rotations, appearing there, shall be given particular values, homogeneously depending upon torque (twisting moment) and two transverse forces. Nevertheless, this detail confirms once more the insufficiency of the classical solution. M. Janusz, Poland

2771. Syutkin, N. F., Jumplike deformation in the linear "elastic" range of the strain diagram, Nat. sci. Found. tr-74, Sept. 1953; *Dokladi Akad. Nauk SSSR (N.S.)* **91,** 1, 83–85, July 1953.

Stress-strain curves were obtained for aging zinc-aluminum alloy in the form of wires (2 and 2.3-mm diam, 30 and 35 mm long) in which elastic as well as plastic region of curve is serrated. Tests were run at temperatures of 0 C to 375 C and at deformation rates of 2×10^{-4} and 2×10^{-2} cm/sec. Rate of strain was obtained by estimating the rate of travel of a light spot (presumably operated by a stress-strain recorder) from the intensity of its trace on a photographic plate. Author concludes that mechanism responsible for "physical" yield point is analogous to the mechanism responsible for first "jump" in an aging alloy.
S. Goodman, USA

2772. Foust, A. S., Conditions in heat transfer problems which create high thermal stress, "Heat Transfer," a Symposium, Univ. of Mich. Press, Ann Arbor, Mich., 1–7, 1953.

Author classifies title conditions into problems of (a) heating rates of solid materials the temperature of which must be changed rather suddenly, and (b) steady-state conditions including high-temperature gradients. As important examples of group (a) he mentions the problem of controlled rates of start-up and shut-down or other operations in which temperature is involved, and the occurrence of stress cracks in heat-treated pieces of metals. As the most important problem of group (b), he considers the design of tube walls for heat transfer from metal, molten in an atomic energy reactor, to a fluid which, in turn, serves as the energy supply for conventional engines in commercial applications. Such a problem is considered more serious than the similar one of boiler tubes because of higher temperatures being developed in the molten metals, which cause steeper temperature gradients, and the higher level of operating temperature at which the material properties are less favorable. A qualitative picture of the stress distribution in such tubes, based on an elastic analysis, is given and the effect of the essential design parameters (which are considered to be the physical properties of the materials, the geometry of the system, and the temperature difference between walls) is briefly discussed. G. A. Zizicas, USA

Experimental Stress Analysis

(See also Revs. 2734, 2787)

2773. Waidelich, A. T., Strain gage tests on prestressed concrete beams, Canadian Conf. on Prestressed Concrete, 1954, University Extension, University of Toronto. B-1–B-7, 27 figs.

Paper covers SR-4 measurements, by the Austin Company, on one 40-ft and one 60-ft prestressed beam to verify some design assumptions. Deformations used to compute location of neutral axis at various flexural moments below and above design load and similar measurements on elongation of prestressing steel may be of use in overload considerations. Typical buildings are also described. R. Quintal, Canada

2774. Russell, J. G., Wake survey and strain-gauge measurements on an inclined propeller in the R.A.E. 24-ft tunnel. Part I. Wake Survey, *Aero. Res. Counc. Lond. curr. Pap.* **117,** 61 pp., Feb. 1952, published 1953.

When the thrust axis of a propeller is inclined to the flight path, the air loads on the blades vary in an approximately sinusoidal manner and give rise to vibratory stresses with a fundamental frequency equal to the propeller rotational speed. Report describes tests carried out in the RAE 24-ft wind tunnel with a 16-ft diam, 4-bladed propeller. Wake survey and blade strain-gage measurements were made at tunnel speeds of around 130 fps with the propeller axis inclined at angles of 0, 5, 10, and 15° to the air flow. The blade angles and propeller rotational speeds were also varied within the limits imposed by the 1500-hp electric motor. The lift grading curves at the points of maximum and minimum loading, derived from total head measurements made in the slipstream by means of a pitot comb, have been compared with estimated values, and estimated power absorption figures compared with measured values.

It is concluded that the method of estimating the fluctuating lift loading put forward in this report is reasonably accurate.
From author's summary

2775. **Sjöström, S., Determination of residual surface stresses with the aid of resistance wire strain gauges,** *Appl. sci. Res.* (*A*) **4,** 4, 305–312, 1954.

A method due to Stäblein for determining surface residual stresses is modified. For stress determination, thin layers of an initially flat test bar are polished away. Instead of measuring the change in curvature, the change in strain on the surface opposite the removed layers is measured with a resistance-wire strain gage. From the assumptions that the residual stresses are constant in surfaces parallel with the polished one and that the transverse and thickness stresses can be neglected, an expression is derived connecting change in strain with initial residual stress in the bar. As an example of the practical application of the method described, the results of a determination of the residual surface stresses in a case-hardening gear-tooth steel are reported.
From author's summary

2776. **Brachet, R., Measurements with resistance wire** gages (in French and English), *Laboratories* no. 7, 13–29, Sept. 1953.

2777. **Barker, R. S., Self-temperature-compensating SR-4 strain gages,** *Proc. Soc. exp. Stress Anal.* **11,** 1, 97–104, 1953.

Tests of the type EBD-3D gages on $^1/_2$-in. round tensile specimens made of 14S-T6 and 75S-T6 were made to check the accuracy of the temperature compensation. The results showed an error of less than ±20 microinches between +60 and +280 F. Beyond this the accuracy fell off rapidly, though the compensation was not affected by cycling beyond the accurate range. The accuracy is improved slightly by cycling several times beyond the expected temperature range. Even though this particular gage has been discontinued, similar sizes and types of temperature compensating gages have shown similar performance.
C. R. Freberg, USA

2778. **Yates, J. G., Lucas, D. H., and Johnston, D. L., Pulse-excitation of resistance strain gauges for dynamic multi-channel observation,** *Proc. Soc. exp. Stress Anal.* **11,** 1, 35–44, 1953.

An equipment is described which makes it possible to display the output signals of 10 strain-gage bridges simultaneously on the screen of a 6-in. cathode-ray tube. The strain-gage bridges are excited in succession by means of pulses of short duration, so that a common output amplifier can be employed. The over-all sensitivity is such that a strain of 0.001% gives a deflection of 1 mm on the screen of the cathode-ray tube. The frequency range is from zero up to about 2000 cps. There are two possibilities of display, the "amplitude" display, where the 10 indications of the strain-gages are placed on a horizontal row as 10 equally spaced dots, and the "wave-form" display, where the 10 indications are placed in the same way on a vertical row. As the strain is indicated by vertical displacements of the dots, the "amplitude" display is useful for static measurements and the "wave-form" display for dynamic measurements, either visually by means of a built-in adjustable time base or by recording the displacements with a continuous-motion film camera. R. G. Boiten, Holland

2779. **Beckmann, G., X-ray stress determination with a spherically bent film** (in German), *Feingerätetechnik* **3,** 1, 15–19, 1954.

Camera is described which uses spherically bent strips of film in the form of a cross, thus permitting focusing at any diffraction angle in two mutually perpendicular planes in normal exposure. It is not clear how the same advantage is achieved in the oblique exposure unless the beam is very narrow, in which case the purpose of focusing is greatly reduced. D. Rosenthal, USA

2780. **Benham, P. P., Bending moments in fuselage frames obtained by the photoelastic method,** *J. roy. aero. Soc.* **57,** 515, 667–682, Nov. 1953.

Paper describes the stress analysis of models of several aircraft fuselage frames. Models studied include frames under plane stress and shell-supported frames. Bending moments determined photoelastically are compared with available theoretical data. While results are too specific to be widely useful, reviewer believes that details of experiments on shell-supported frames are of practical interest. W. Shelson, Canada

2781. **Jessop, H. T., and Stableford, W. H., A method of correcting for initial stresses in frozen-stress observations,** *Brit. J. appl. Phys.* **4,** 9, 281–283, Sept. 1953.

Formulas are derived by the use of which it is possible to correct observations on a slice of a "frozen" model for such initial stresses as cannot be removed by annealing. It is demonstrated also that mottle in Marco resin produces an optical effect similar to that of a stress difference, and that this method of correction may be applied to mottle effects when these are sensibly uniform through the thickness of a slice of the materials.
From authors' summary by A. F. C. Brown, England

2782. **Martin, A., Photoelastic measurements in France** (in French and English), *Laboratories* no. 7, 31–43, Sept. 1953.

2783. **Ryder, F. L., Electrical analogs of statically loaded structures,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 376, 24 pp., Dec. 1953.

In the analogous electrical circuit, force and moment are simulated by current, and deflection and slope by voltage drop. The analogy is based on the fact that Castigliano's theorem and the principle of least work have their counterparts in certain electrical networks. The theory is developed for the two-dimensional and three-dimensional truss, and for two-dimensional rigid frames and truss-frame combinations, including trusses with secondary stresses. A working model is described. Experimental results that are accurate to 2.5% of the maximum values have been obtained.
From author's summary by M-L. Pei, USA

2784. **Demorest, D. J., and Leeser, D. O., A study of residual stresses in flat beams by electropolishing methods,** *Proc. Soc. exp. Stress Anal.* **11,** 1, 45–54, 1953.

Residual stresses set up in copper strips by cold rolling and cold drawing were determined by electropolishing techniques. Stresses were computed from measurements of curvature changes as successive layers were removed from the specimens by electrolytic action. Specimens of $^1/_4$-in. × $^5/_{16}$-in. × 5-in. size were mounted in a jig designed to provide uniform current density over one surface, and approximately 0.001-in. thickness was removed per 10 minutes until the specimen was reduced to one-half original thickness. Removal of material by this technique should avoid disturbances caused by conventional machining or acid-etch methods. Changes in specimen curvature were measured by an SR-4 strain gage mounted on the back of the specimen. Cold-worked thickness reductions varied from 12% to 68%. In accordance with previous work on a similar material, surface resid-

ual stresses were found to be tensile, while the subsurface stresses depended upon degree of plastic deformation.

D. E. Hudson, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See Revs. 2754, 2755, 2759, 2764, 2801, 2809, 2822, 2832, 2850, 2852, 2855, 2863)

Plates, Disks, Shells, Membranes

(See also Revs. 2761, 2764, 2799, 2800, 2801, 2804, 2805, 2827, 2843, 2848, 2849)

2785. Langhaar, H. L., and Carver, D. R., On the strain energy of shells, *J. appl. Mech.* **21,** 1, 81–82, Mar. 1954.

In a previous paper [AMR **3,** Rev. 1641] of the first author, the strain energy was derived with the assumption that only the linearized terms in the thickness coordinate z need be retained in the geometrical equations between the strains and the displacements of the middle surface. The present paper shows that, in general, the strain-energy density is only a rational funtion of z, and the evaluation of the strain energy in terms of the displacements is not difficult. In the simple example of the cantilever curved beam the authors point out that the linearizing of the geometrical equations in connection with the use of strain energy and calculus of variations leads to questionable approximations. The conditions of equilibrium are not satisfied; the net tension disagrees grossly. But if the shell is thin, the linearizing causes only a small error in the stresses. H. Schaefer, Germany

2786. Dahl, N. C., Toroidal-shell expansion joints, *J. appl. Mech.* **20,** 4, 497–503, Dec. 1953.

A thin toroidal shell is slit along its inner edge and welded to cylindrical pipe sections to form an Omega joint. Stresses and axial deformation are desired. The solution of this problem, both for small and finite deformations, has been given by R. A. Clark and E. Reissner [AMR **4,** Rev. 2429; **6,** Rev. 3364] using asymptotic expansions in terms of a parameter $\mu = [12(1-\nu^2)]^{1/2} b^2/ah$ (b is torus midsurface radius, a is centerline radius, h is thickness).

Restricting himself to small deformations, author obtains a solution, valid for small μ, by means of the principle of minimum complementary energy. Conventional stress resultants are expressed in terms of the change β of the tangent angle. A Fourier series is assumed for β. Only the first four terms of the series are retained, and the corresponding coefficients are determined by minimizing complementary energy. An alternative procedure is indicated which makes use of the horizontal and vertical stress results as suggested by E. Reissner.

A comparison of the asymptotic solution as obtained by Clark and of the energy solution shows good agreement in the intermediate range of μ where the two solutions overlap. The asymptotic solution should not be used for $\mu < 10$ and the energy solution should not be used for $\mu > 30$.

H. Parkus, USA

2787. Schlechte, F. R., and Rosecrans, R., Experimental stress analysis of stiffened cylinders with cutouts. Pure bending, *NACA TN* 3073, 41 pp., Mar. 1954.

Bending tests were made on a cylindrical semimonocoque shell of circular cross section. The cylinder was tested without a cutout and then with a rectangular cutout which was successively enlarged through six sizes varying from 30° to 130° in circumference and from 1 to 2 bays in length. Strain measurements were made with resistance-type wire strain gages near the cutout on the stringers, the skin, and the rings for each size of cutout, and the stresses obtained are presented in tables.

From authors' summary

2788. Gray, R. T., Boothe, W., and Horvay, G., Stresses in cylindrical pressure vessels partially supported by soil, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-82, 9 pp.

Authors consider a cylindrical pressure vessel where the bottom portion is encased in concrete (the longitudinal axis is vertical). This paper concerns the bending stresses that develop at the interface where the built-in and free portions join. Curves are presented which indicate the reduction in bending stresses that can be achieved near the built-in end by the application of partial elastic support in the vicinity of the built-in zone. The partial elastic support is achieved by means of sand dammed up to various depths. J. Aronofsky, USA

2789. Naghdi, P. M., and Berry, J. G., On the equations of motion of cylindrical shells, *J. Appl. Mech.* **21,** 2, 160–166, June 1954.

Authors consider a closed cylindrical shell, very thin as compared with the mean radius. The boundary conditions are arbitrary. The shell is prestressed by a static load and is subjected to a time-dependent load as well. Using Love's simplifying assumptions, the authors derive three simultaneous partial differential equations which, in the absence of time-dependent loads, become equations of equilibrium, or equations of motion if time-dependent loads are present. Every equation contains three dependent variables as functions of three independent variables (displacement components as functions of space coordinates and time). These equations are "uncoupled," which means converted into an equivalent system of three equations where one equation contains only one dependent variable, or two at the most. This transformation complicates the equations considerably, raising their order from eight to sixteen. The reason for doing it is not very clear because they are not being solved. The solutions, i.e. the components of displacement, are written down as infinite series with unknown coefficients. They are substituted in the differential equations which yield three equations in coefficients of the series. By setting the determinant of these coefficients equal to zero (which is the condition for a nontrivial solution), a characteristic equation is obtained. The authors' characteristic equation is compared then with similar equations obtained by other investigators, and the differences and similarities are discussed in detail. The only conclusion the authors draw is that a very small advantage is gained by going beyond Love's first approximation.

T. Leser, USA

2790. Schwalbe, W. L., Conjugate load method in analysis of thin shells, Proc. First Midwestern Conf. Solid Mech., Engng. Exp. Sta., Univ. of Ill., 74–76, Apr. 1953.

Author decomposes the shell into two intersecting systems of bands mutually perpendicular. Each band has only one infinitesimal dimension. By means of well-known theory of elasticity, author calculates the part of the external load taken by each system of the imaginary bands and develops formulas for the laterally loaded plate. He does not mention in which field of engineering practice his formulas meet a need. Article contains some misprints. M. Kuipers, Holland

2791. Pettersson, O., Circular plates subjected to radially symmetrical transverse load combined with uniform compression or tension in the plane of the plate, *Tekn. Skr., Stockholm* no. 153, 30 pp., Dec. 1953.

Author makes an exhaustive treatment of the circular plate for uniform transverse loads and compressive edge loading on the basis of the classic theory of small deflections. The characteristic equation contains two Bessel functions of the first kind and its roots yield the critical buckling values. In terms of the ratio N/N_c author finds an approximate deflection expression for the deflection $w = w_q/(1 \pm N/N_c)$ where w_q is the deflection due to transverse loading alone, N compressive edge load, and N_c the critical edge load for the first mode of buckling. The $\pm$ signs accompany tensile and compressive edge loads. Similar approximate expressions are found for final curvatures in terms of curvatures for only transverse loads. A modification of the latter expressions is effected and suitable coefficients are tabulated for a variety of transverse loads and changed edge conditions. No attempt is made to compare the results with the nonlinear results of large deflections and their accompanying skin effect.

D. L. Holl, USA

2792. **Pettersson, O., Plates subjected to compression or tension and to simultaneous transverse load,** *IngenVetenskAkad. Tidsk. Tekn. Forsk.* **25,** 2, 78–82, 1954.

Author continues his same study (see preceding review) to a rectangular plate with simply supported edges and axially compressed in one direction. Extended approximate formulas are reported in the form $K/K_q = [1 \pm \alpha(N/N_c)/1 \mp (N/N_c)]$ where K refers to a final deflection or curvature, K_q a deflection or curvature due to transverse loads only, and α is a dimensionless parameter involving maximum values at the center of the plate, at least one of which is critical at the stage of impending buckling. (The upper signs imply the compressive edge loading.)

D. L. Holl, USA

2793. **Das, S. C., On the effect of shearing stresses applied on the boundary of a circular hole in a semi-infinite plate,** *Indian J. theor. Phys.* **1,** 2, 79–86, Sept. 1953.

Plane bipolar coordinates are used to calculate the stresses due to applied tangential forces on the inner boundary of a circular hole near the straight edge of a semi-infinite plate. Such a shear can be produced by a rotating shaft in a circular hole near the straight edge of a semi-infinite plate. The stresses are calculated from a stress function due to G. B. Jeffrey [*Phil. Trans. roy. Soc. Lond.* (*A*) **221,** 265–293, 1921]. Values of the stress along the straight edge of the plate are tabulated for various hole sizes and locations. The maximum stress along the straight edge, due to a couple acting in the plane of the plate, is calculated. The latter result was obtained by S. Ghosh [*Bull. Cal. math. Soc.* **29,** 177–184, 1937] by an entirely different method.

J. H. Baltrukonis, USA

2794. **Pickett, G., and Janes, W. C., Bending under lateral load of a circular slab on an elastic solid foundation,** Proc. First Midwestern Conf. Solid Mech., Engng. Exp. Sta., Univ. of Ill., 112–118, Apr. 1953.

Authors treat a finite circular thin plate resting upon an elastic layer of thickness t. The layer base is homogeneous, isotropic, infinite in horizontal extent and rests on a rough rigid base. Thin-plate theory is applied to the plate and three-dimensional theory to the elastic layer. In the axially symmetric case of plate and layer, the plate has a loading over a central area of the plate of radius $b \leq a$, the free edge of the plate. There is no tangential friction between the plate and layer. The pressure and deflection of the plate are equated, respectively, to the pressure loading and surface deflection of the elastic layer. In establishing these identities so as to be valid in the range $0 \leq r \leq a$, authors are led to infinite integrals to express the coefficients of the linear infinite system of equations which determines the constants. Finally, some seven constants are evaluated for several values of the parameters of relative stiffness ratio of two media, and the ratio b/a.

Reviewer questions the possible contact of the plate and the subgrade for all values $0 \leq r \leq a$. This is especially true for concentrated loading, a large plate, relatively weak in stiffness compared to that of the base. Again, a very stiff plate with sufficient border loading and a weak base will have a cutting pressure at the edge $r = a$. Even in other cases, authors acknowledge difficulty in the convergence of their results; for example, one graph shows a negative pressure reaction accompanying a positive deflection of the plate into the subgrade surface.

D. L. Holl, USA

2795. **Sengupta, H. M., On the bending of an elastic plate. III, IV,** *Bull. Calcutta math. Soc.* **44, 45,** 3, 1; 111–123, 9–19, Sept. 1952; Mar. 1953.

The transverse deflection of a thin elastic plate, elliptic in shape and built in along its edge, is found for (1) uniform load along a straight line parallel to either of the axes of the bounding ellipse, and (2) uniform load over a rectangular region with its sides parallel to the axes of the bounding ellipse. No numerical results are given.

H. G. Hopkins, USA

2796. **Woinowsky-Krieger, S., Bending of plates under the action of concentrated forces** (in German), *Ing.-Arch.* **21,** 5/6, 331–338, 1953.

Concentrated loads acting on plates create infinite stresses. For this reason it is desirable to have formulas which give the stresses when the loads are distributed uniformly over small circular or rectangular areas. A. Nadai in 1921 derived such formulas for the center of a loaded circular region when the plate was circular. (The region center was, in general, eccentric to the plate center.) Author extends the method to the case of rectangles loaded uniformly over small rectangular regions (and also to some other special cases). The simple formulas, to be used with some auxiliary tables that are furnished, agree very well with the solutions obtained by lengthy conventional calculations.

G. Horvay, USA

2797. **Eggwertz, S., and Norr, A., Analysis of thin square plates under normal pressure and provided with edge frames of finite stiffnesses in the plane of the plates,** *Flygtekn. Försökanst. Medd.* no. 50, 34 pp., 1953.

Deformations and stresses are studied for thin square plate subjected to uniform normal pressure. Plate edges are supported by stiffeners which prevent deflections perpendicular to the plane of the plate. Using energy method and neglecting bending of plate, simple formulas are derived for deflections and membrane stresses, including influence of stiffener stiffness. Rough estimate is made of bending moments as well as of their contribution to the transmission of the total load to the supports. Test values from plates of different thicknesses and with different edge frames are presented in diagrams and compared with theoretical results. The coefficients of the membrane-theory equations are finally modified to give curves in close agreement with the test results for comparatively large deflections.

From authors' summary by S. Levy, USA

2798. **Krettner, J., Theory and application of skew plates** (in German), *Ing.-Arch.* **21,** 2, 112–118, 1953.

Paper contains an easy-to-use compilation of basic formulas for stress and strain in tensor notation. These formulas are used to derive the basic equations for an elastic plate, using a skew rectilinear coordinate system. Solutions of these equations are announced for a following paper.

W. Flügge, USA

Buckling Problems

(See also Rev. 2820)

2799. Dow, N. F., Levin, L. R., and Troutman, J. L., Elastic buckling under combined stresses of flat plates with integral waffle-like stiffening, *NACA TN* 3059, 19 pp., Jan. 1954.

Theory and experiment are compared and found in good agreement for the elastic buckling under combined stresses of long flat plates with integral waffle-like stiffening in a variety of configurations.

For the buckling of such flat plates, 45° waffle stiffening was found to be the most effective of the configurations for the proportions considered over the widest range of combinations of compression and shear.

From authors' summary by P. C. Dunne, England

2800. Bijlaard, P. P., and Johnston, G. S., Compressive buckling of plates due to forced crippling of stiffeners—Parts I and II, Sherman M. Fairchild Prep. 408, 39 pp., Jan. 1953.

Extensive theoretical methods are developed for buckling of sheet involving, also, distortion of stiffeners or webs. Post-buckling and inelastic effects are included. Working formulas and comparisons of results with test data are presented. It is shown that this type of failure can be avoided or minimized by certain design practices, such as the use of integrally stiffened members. F. R. Shanley, USA

2801. Neuber, H., Simplifications of the basic equations of elastic stability with applications to beams, plates, and shells (in German), *ZAMM* **33,** 8/9, 286–290, Aug./Sept. 1953.

Present paper is a continuation of author's previous investigations on the same subject and is concerned with the change on the prestress-tensor due to the deformation at the point of indifferent equilibrium, and the effect this may have on the solution of stability problems. Author has previously shown these to be second-order effects and proved that they do not alter the buckling load in a number of cases of practical importance. Because of this, it is only necessary to give an approximate formulation of the problem which will make the solution easier to obtain; the present paper gives a new expression for the prestress tensor in addition to two given previously by the same author. Buckling of columns and plates is treated more in detail as examples, and the known results are confirmed. The author promises to treat the buckling of shells in a paper to be published.

L. N. Persen, USA

2802. Goldhammer, B. F., The effect of load and initial shape on location of inflection points of fixed-ended columns, *Proc. Soc. exp. Stress Anal.* **11,** 1, 129–136, 1953.

Author shows how points of inflection of imperfect fixed-ended columns shift with increase of load, and, therefore, that determinations of free lengths at less than critical load are unreliable for estimating free lengths at critical load.

W. R. Osgood, USA

2803. Bornscheuer, F. W., Example and collected formulas on the stress analysis of thin-walled nonbuckling beams (in German), *Stahlbau* **21, 22,** 12, 2; 225–232, 32–44, Dec. 1952, Jan. 1953.

2804. March, H. W., and Kuenzi, E. W., Buckling of sandwich cylinders in torsion, *For. Prod. Lab. Rep., U. S. Dept. Agric.* no. 1840, 31 pp., June 1953.

The critical buckling stress is obtained by a conventional energy method which takes account of both bending and extensional strain. A sinusoidal buckling shape is assumed in which the undetermined parameters are the number and orientation of the waves, whose amplitude is made to vanish at the two ends of the cylinder. The isotropic core resists only shear strain, which is assumed constant across the core thickness, but the unequal facings are orthotropic. Tables and curves give theoretical results for different arrangements, and an appendix treats the case of the orthotropic core. D. Williams, England

2805. Berger, E. R., An approximate form for the calculation of the buckling force of a concentrically compressed cylindrical shell (in German), *Beton u. Stahlbeton.* **48,** 12, 288–289, Dec. 1953.

2806. Hoff, N. J., and Bruce, V. G., Dynamic analysis of the buckling of laterally loaded flat arches, *J. Math. Phys.* 32, 4, 276–288, Jan. 1954.

Paper extends the static treatment of the "Durchschlag" problem [see e.g., Biezeno-Grammel, "Technische Dynamik"] by developing the equations governing the dynamic response of a flat arch to time-dependent lateral forces. These equations, after linearization, are used to investigate the stability of the equilibrium configuration corresponding to the quasi-static case of slowly applied loads. The response to impulsive forces of varying duration is also studied.

Buckling criteria are developed for both cases. It is shown that the magnitude of the critical loads is materially influenced by their duration. E. F. Masur, USA

2807. Sattler, K., The stability of multistory bents held against sidesway (in German), *Öst. Bauzeitschr.* **8,** 11, 12; 62–64, 65–68, Nov., Dec. 1953.

Lindquist's well-known series criterion [*NACA TN* 617] for the stability of trusses is applied to title problem. The applicability of the procedure is obvious. E. F. Masur, USA

2808. Stüssi, F., Some buckling problems (in German), *Mitt. TKSVB* no. 8, 209–234, 1953.

2809. Goodier, J. N., Some observations on elastic stability, Proc. First U. S. nat. Congr. appl. Mech., June 1951; J. W. Edwards, Ann Arbor, Mich., 193–202, 1952.

As the title points out, the paper does not give a thorough treatment of one or several stability problems but rather a (very interesting) survey of the physical phenomena connected with these topics: The Euler beam with large deflections or with a nonlinear lateral spring; the "oil-canning" of bars and shells; the eigenvalue problem of plates, particularly of the sandwich type; elastic foundation as connected with sandwich problems; lateral buckling for $I_1 \approx I_2$ where (due to the compression of parts of the fibers) the torsional stiffness may be reduced to 0 so that the nonlinear terms of large torsion become significant. Phenomena of the last type are shown in some striking experiments.

K. Marguerre, USA

Joints and Joining Methods

(See also Rev. 2786)

2810. Hughes, J. E., The cold pressure welding of metals, *Metallurgia, Manchr.* **49,** 291, 15–19, Jan. 1954.

Using a method of cold-welding cylindrical rod specimens in which the deformation may be confined to the interfacial zone, the

weldabilities of aluminum, copper, and iron have been studied. Results on combination welding suggest that the factors which determine the weldability of a metal play a significant part when the metal is welded to another. The metal-oxide relative hardness theory is discussed. From author's summary

2811. **Shepheard, R. B., Aspects of welding research in British merchant shipbuilding,** *Welding J.* **33,** 1, 23–40, Jan. 1954.

The importance of adequate notch toughness at service temperature in mild steel is stressed and recent researches in welding aluminum alloys, residual stresses, full-scale structural tests on welded and riveted ships, and structural components are covered. From author's summary

2812. **Hormann, E., Induction welding: longitudinal welding of tubes and its application** (in German), *ZVDI* **96,** 3, 65–72, Jan. 1954.

2813. **Huff, H. A., Jr., and Kugler, A. N., Welding and brazing of tubes to the tube sheets for unfired heat-transfer equipment,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-175, 13 pp.

The general problem of fabricating heat exchangers, in so far as the tube-tube sheet assembly is concerned, generally involves metals of differing thicknesses and under some circumstances may require the joining of dissimilar metals. This paper discusses the methods of joining tubes to tube sheets by welding and brazing processes and the influence of the variables of thickness and metal analyses upon these processes. From authors' summary

2814. **Grover, LaM., Design and research for welded structures,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 343, 27 pp., Nov. 1953.

2815. **van der Willigen, P. C., and Defize, F. L., The determination of droplet size in arc welding by high-speed cinematography,** *Philips tech. Rev.* **15,** 4, 122–128, Oct. 1953.

Systematic measurements have been carried out to ascertain the size of the droplets of weld metal transferred from welding electrodes to the work. For this purpose, films of the welding arc were made at a picture frequency of up to 3000 per sec. For the background a light of such brightness was used that the droplets were filmed in silhouette, notwithstanding the brilliant light emitted by the arc itself. Some of the measurements are discussed.

Color films have also been made, at the same frequency, to give a more general impression of the processes taking place during welding. Certain features observed in the film are briefly reviewed. From authors' summary

2816. **Barrett, J. C., Lane, I. R., Jr., and Huber, R. W., Effect of atmospheric contaminants on arc welds in titanium,** *Weld. J.* 32, 6, 283s–291s, 16 figs., June 1953.

The effect of gaseous contaminants on the properties of arc welds in titanium is studied. An attempt is made to determine the minimum content of each which would have a detrimental effect on the bend and tensile properties of the weld. It was found that a titanium weld made in a pure helium atmosphere has properties comparable to those of the parent metal tested in tension and bending. The relative humidity of the helium atmosphere should be lower than 5% to produce a weld comparable with those made in pure helium. Helium atmospheres containing nitrogen or oxygen must contain considerably less than 1% by volume of each of these gases if properties are to approach those of welds made in pure helium. Hydrogen up to 10% did not cause any drastic lowering of tensile and bend properties.

J. N. Thompson, USA

2817. **Pearmain, G. J., Practical application of the new British standard system of limits and fits,** *Engineer, Lond.* **196,** 5109, 848–852, Dec. 1953.

2818. **Frey, K., The strength of metal joints made with synthetic resins,** *Aircr. Engng.* **25,** 296, 317–320, Oct. 1953.

The use of synthetic resins in the joining of metal joints involves different problems from those pertaining to joints between metal plates or members in which the joining material is also a similar metal. It is no longer possible to assume that local inelastic deformations will permit utilization of all or nearly all of the joining material at its average strength level. The nonuniformities of stress distribution in all joints will markedly affect the strength when the joining material has considerably less unit strength than the parts being joined. The possibility of using a more flexible joining material, so as to produce a more uniform stress distribution, creates the disadvantage that deformable adhesives have smaller breaking strengths and are liable to creep, particularly at elevated temperatures. Consequently, it is desirable to use relatively rigid adhesives and determine the optimum practical utilization of both adhesive and metal as determined by yield point, choice of metal thickness, and geometry of the connection.

Tests of a considerable number of simple lap joints are reported and the relationship between the shear strength and the geometry of the test specimen is investigat d. Rules are developed for the optimum utilization of strength of adhesive and metal. The yield strength of the metal is shown to determine the choice of sheet thickness and overlap of the simple lap joint. Formulas and graphs are presented for design. Author states that the use of synthetic resins as adhesives for metals and other known porous materials opens up new possibilities in a whole range of industries, with many practical applications which are steadily increasing in number. B. G. Johnston, USA

2819. **Barkeling, E., New wood construction in Sweden** (in German), *Bautechnik* **30,** 10, 308–309, Oct. 1953.

The joints of the nailed built-up lumber truss are reinforced with toothed steel plates through which the helically threaded nails are driven. As a result of this reinforcement of the joints, the stiffness and load-carrying capacity of the truss are considerably increased despite the fact that the number of nails is reduced from the customary number.

Typical test data on the joints are presented. More than 300 Swedish structures have used this type of construction to date.

E. G. Stern, USA

Structures

(See also Revs. 2742, 2753, 2756, 2773, 2780, 2783, 2788, 2804, 2806, 2807, 2850, 2851, 2852, 2865, 2870, 2873, 2876, 3050, 3052, 3054, 3059, 3061)

2820. Pucher, A., Handbook of reinforced-concrete structures. Principles and application in buildings and bridges [Lehrbuch des Stahlbetonbaues. Grundlagen und Anwendungen im Hoch- und Brückenbau], 2nd ed., Wien, Springer-Verlag, 1953, x + 331 pp., 321 figs. $7.60.

This second edition (1st ed. in 1949) of this excellent handbook contains many additions and improvements, especially in the

following subjects: Thorough presentation of Engesser's theory of column design; stability of slender arches; deflection in a plastic stage and application to design. Author purposely omitted discussion of prestressed concrete with its recent enormous developments, which require a special book. On the other hand, the handbook contains condensed results of practically all research and applications of reinforced concrete. A substantial part of the book pertains to concrete bridges, their thorough analysis and recent construction methods. American Hardy Cross method of moment distribution is thoroughly explained and demonstrated in examples. Numerous nomographs, diagrams, and tables are useful for designers. J. J. Polivka, USA

2821. Cowan, H. J., The design of prestressed concrete beams subject to secondary shear and torsion, *Civ. Engng., Lond.* **48, 49,** 570, 571; 1141–1142, 67–69, Dec. 1953, Jan. 1954.

2822. Pirson, E., A method of design for the ends of prestressed concrete girders (in French), *Ann. Trav. publics Belg.* **106,** 3, 401–436, 2 charts, June 1953.

A method of design is presented with examples by which maximum economy may be achieved in the design of the ends of prestressed concrete girders. The economy is achieved by placing the prestressing cables so that they follow the normal stress trajectories in the end anchorage. C. F. Peck, Jr., USA

2823. Moncrieff, D. S., The effect of grading and shape on the bulk density of concrete aggregates, *Mag. Concr. Res.* no. 14, 67–70, Dec. 1953.

Paper presents experimental data from laboratory tests.
C. J. Bernhardt, Norway

2824. Rogers, G. L., Validity of certain assumptions in the mechanics of prestressed concrete, *J. Amer. Concr. Inst.* **25,** 4, part 1, 317–330, Dec. 1953.

Author compares load required to produce first tensile crack in two-way prestressed slab as calculated from theory of elasticity and as measured in highly controlled test. Close agreement between results shows the theory to be adequate and the cause of important discrepancies described elsewhere to result from other factors, among which support conditions seem to predominate.
R. Quintal, Canada

2825. Ohlig, R., Space structures of reinforced concrete reservoirs (in German), *Beton u. Stahlbeton.* **48,** 10, 233–243, Oct. 1953.

Closed cylindrical shell for silo is treated according to known theory requiring solution of eighth-order differential equation. The following assumptions are made: (a) When expressing moments by displacements, ratio of tangential displacements to radius and their derivatives is neglected in comparison with radial displacements and their derivatives; (b) vanishing Poisson coefficient; (c) uniform mean wall thickness.

The methods of Lagrange and Sturm are used for solution of characteristic equation; forces and moments are expressed in terms of exponential and trigonometric functions. Reactions from equidistant supporting columns are considered as discontinuous distribution and expanded into Fourier series. Reviewer points out that in Lundgren's "Cylindrical shells," to which author refers, calculations and extensive tables are based on a Poisson ratio of 0.2 which is more in accordance with concrete behavior than author's ratio of zero. Z. Chashin, Israel

2826. Thorsen, N., Modern developments in prestressed concrete, *Engng. J., Montreal* **36,** 10, 1278–1286, Oct. 1953.

2827. Girkmann, K., Theory of arched roofs (in German), *Öst. Bauzeitschr.* **9,** 1, 1–6, Jan. 1954.

The theory of the circular cylindrical shell is developed in a simplified manner, applicable for shells with small thickness compared with the radius of curvature. Author obtains a partial differential equation of eighth order. A numerical example shows that the results are in good agreement with other modern methods.
H. Neuber, Germany

2828. Livesley, R. K., Analysis of rigid frames by an electronic digital computer, *Engineering* **176,** 4569, 4570; 230–233, 277–278, Aug. 1953.

Article describes method for analyzing rigid-jointed structures with straight uniform members, using the electronic digital computer at University of Manchester. Deflections (linear and angular) and loads (forces and moments) at both ends of each member are determined. Matrix notation is used throughout. Analysis for plane structures is presented in detail but can be extended to space frames. Numerical examples of rigid portal frame and Vierendeel truss are presented. Method described is limited to plane frames having ten or fewer joints.
W. D. Jordan, USA

2829. Livesley, R. K., and Charlton, T. M., Analysis of rigid-jointed plane frameworks. Use of an electronic digital computor, *Engineering* **177,** 4595, 239–241, Feb. 1594.

Article describes procedure for extending previous method of analysis (see preceding review) to rigid frames having any number of members. Numerical examples are given.
W. D. Jordan, USA

2830. Steinhardt, O., Present status of steel constructions (in German), *ZVDI* **95,** 29, 989–994, Oct. 1953.

A short review is given of the progress in steel construction during and after World War II. Referring especially to the situation in Germany, author presents some examples in modern steel building, such as structural engineering, radio towers, high-pressure tubes, and—more detailed—bridges. Applying theory of slabs and shells as well as considering composite action of steel girder and concrete slab, great economy in steel weight is reached. Author shows typical section of two Rhine bridges with main girders as hollow boxes (tube action) and explains stress action in orthotropic steel plates, which saves weight and height of construction, especially in wide-spanned bridges. Finally, a few examples of progress in welding bridges and a comparison of weights between steel and reinforced-concrete bridges are given. Paper gives news of modern tendencies in German steel building and an extract of the large bibliography concerning it.
H. Beer, Austria

2831. Beaufoy, L. A., Open-spandrel arch analysis assuming continuity of structure, *Publ. int. Assn. Bridge struct. Engng.* 13, 17–47, 1953.

Ingenious analysis of a most complex structural problem. Loading condition chosen (Fig. 17) could, perhaps with advantage, have been more realistic.

Influence line ordinates for terminal forces agree closely with those of Wilson and Kluge's test at Illinois on a structure of identical dimensions. Effect of expansion joints in deck is not studied. Arch rib centering is assumed to be in place until deck is completed—an unusual condition in practice.

Reviewer's work on this problem (1932) leads him to a general agreement with author's qualitative statements regarding deck participation. A. H. Finlay, Canada

2832. **da Cunha Amaral, A. M., Continuous polygonal beams: Application of Hardy Cross method** (in Portuguese), *Mem. Ordem Engrs., Lisboa* **1,** 3, 343–360, 1953.

Referring to a paper of Oscar Rimoldi on the same subject (using three-moments equations), author presents a method based on the principle of moment distribution, originated by Hardy Cross. Stiffness and carry-over factors are calculated for bending and twisting moments by the principles of least work and virtual work. Three examples are thoroughly discussed to demonstrate the advantages of the method. Referring to his paper on generalization of the Hardy Cross method [*Rev. Ordem Engrs.* no. 75, Mar. 1950], author confirms the correctness of the method presented by compatibility conditions.

J. J. Polivka, USA

2833. **Saha, M. R., Indeterminate frame analysis by the method of equivalents,** *J. Instn. Engrs. (India)* **32,** 3, 67–92, Mar. 1952.

Paper describes the "method of equivalents" for application in the analysis of indeterminate frames, with members of uniform cross sections, fully restrained against lateral sway. The principle is based on replacement of complex frames by equivalent simpler ones and is derived from the fundamental equilibrium equations of elastic joints.

More specifically, the method depends on the evaluation of final rotations of different joints under the influence of equilibrating moments by the principle of equivalent replacement of complex frames by simpler ones. These final rotations are the resultants of the algebraic summations of primary rotations of the joints and the induced secondary rotations of the same joints due to the primary rotations of surrounding joints.

The final rotations are substituted in the fundamental deformation equations to obtain the restrained moments at the ends of the different members of the framework.

From author's summary by G. B. White, USA

2834. **Kerekes, F., and Alsmeyer, W. C., Elastic behavior of single-angle members in a trussed tower,** *Iowa Engng. Exp. Sta. Bull.* 173, 47 pp., 1952.

The investigation deals with the effect of end connections on the behavior of single-angle compression and tension members in an aluminum-alloy space-frame tower. Practical design methods are developed on the basis of the observed behavior of the members and the theoretical equations resulting therefrom.

From authors' summary

2835. **Rausch, E., Machine foundations** (in German), *ZVDI* **95,** 28, 967–974, Oct. 1953.

2836. **del Salvatore, A., A method for the calculation of stresses during the landing of an airplane with tricycle landing gear** (in Italian), *Aerotecnica* **33,** 6, 424–428, Dec. 1953.

Purpose of paper is to offer a short and sufficiently approximate method for the analytical determination of the values of stresses acting on the landing undercarriages, with reference to the various cases taken into consideration by the Italian rules on airplane tests.

Starting from the conditions of equilibrium for translation and rotation with reference to the principal axes of inertia of the airplane, the analytical expressions of the impact components in the x, y, and z directions, respectively, are calculated as functions of the dimensional and mass parameters of the aircraft. Moreover, on the basis of the elastic characteristics of the shock absorber, supposed to be known, a method for the determination of the effective maximum stresses is developed.

From author's summary

2837. **Mansfield, E. H., Elasticity of a sheet reinforced by stringers and skew ribs, with applications to swept wings,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2758, 27 pp., Dec. 1949, published 1953.

Theory has been developed for determining the stresses and displacements in a sheet reinforced by stringers and ribs which are not at right angles to the stringers. This theory has been applied to a cylinder of rectangular section stiffened with skewed ribs. It is shown for the cylinder that there exists axes about which applied moments produce pure twist or pure curvature. Simple formulas are included for determining these axes and for obtaining the relationships between twist and curvature and applied moments.

From author's summary by S. Lampert, USA

2838. **Anderson, A. W., and Burgan, E. T., Wind-tunnel investigation of the forces and moments on several types of bridge models,** *David W. Taylor Mod. Basin Rep.* 858, 23 pp., 30 figs., Aug. 1953.

Wind-tunnel studies are used to investigate wind forces and moments on scale models of three types of bridges: the pony truss, the plate girder, and the through-truss over a wide range of yaw and pitch angles. Data for study were secured from experimental findings obtained by placing models in an 8×10-ft wind tunnel and a 2×3-ft Smoke Facility tunnel.

Results show for pony truss, and especially through-truss, a similarity to flat-plate theory, while girder type does not conform to same.

Report is comprehensive with respect to results obtained, with excellent graphical illustrations. No recommendations are made with respect to design procedures, the ultimate end of such an experimental study. F. L. Castleman, Jr., USA

2839. **Széchy, K., Novel methods of design of bridge abutment walls** (in German), *Acta Techn. Hung. Budapest* **7,** 1–2, 89–122, 1953.

While considerable progress has been made during the last decade on both construction materials and design for the superstructure of bridges, substructures, especially abutments, are still designed in the traditional way as gravity walls and are thus very uneconomical, though the costs of the substructure form a substantial part of the total outlay. Author makes suggestions for the numerical consideration of "hidden reserves" hitherto disregarded in abutment design, as well as for the application of novel structures in bridge head construction.

One suggestion is to consider passive earth pressure, which leads to more economic design. For example, the abutment, loaded by earth pressure and the usually eccentrically transmitted reaction from the bridge, suffers tilting and horizontal displacement because of soil compression, in consequence of which passive earth pressure acts on side wall of abutment foundation.

The magnitude of earth pressure acting on abutment and wing walls is further investigated: the routine two-dimensional calculation method considering an earth mass of infinite length neglects the fixed-in condition of the earth mass behind the retaining wall and results in substantially larger earth pressure. Author therefore computes the reduction of pressure on the abutment due to friction arising on wing walls and determines the earth pressure on wing walls by the silo-pressure theory.

For the computation of additional pressure caused by live load, author suggests considering the stress-reducing effect of more rigid pavements by the two-layer theory.

The last part of the paper deals with bridge-head design and suggests bridge heads of short span (5–8 m), bridges to be built not as conventional gravity walls but as reinforced-concrete structures abutted at their tops by the bridge superstructure

itself. The retaining wall will thus be substantially thinner, more economical, and settling of the footings will not stress the structure harmfully as, e.g., is the case in frames. The paper presents numerical examples worked out in detail, referring to all problems treated and thus proving the importance of this novel method of calculation. A. Kézdi, Hungary

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 2820, 2871, 2877, 2881, 2882)

2840. Ford, H., The theory of plasticity in relation to its engineering applications, *ZAMP* **5,** 1, 1–35, 1954.

Paper contains a survey of some of the main lines of investigation in plasticity. Part of the mathematical theory is too sketchy to be of much use and contains a number of misprints. The Reuss equations are incorrectly stated. Problems dealt with include plastic bending under tension, plane strain, and the slip-line field. Among the problems dealt with are extrusion of flat sheet, compression between smooth platens, and the rolling of metal sheets. An unpublished investigation into friction in cold rolling is referred to. W. M. Shepherd, England

2841. Krieger, I. M., and Maron, S. H., Direct determination of the flow curves of non-Newtonian fluids. III. Standardized treatment of viscometric data, *J. appl. Phys.* **25,** 1, 72–75, Jan. 1954.

The previous methods for obtaining rate of shear vs. shearing stress curves of a non-Newtonian fluid [see AMR **6,** Rev. 3398; **5,** Rev. 1718] are unified, in this paper, by introducing the apparent fluidity function ϕ_a. With the aid of this function, it is found that the rate of shear $g(F)$ is related to the shearing stress F by an equation of the form $g(F)/F = \phi_a[1 + \Delta(F)]$. Methods are presented for obtaining the correction term $\Delta(F)$ from capillary and concentric cylinder viscometric data.

When the authors studied the same non-Newtonian fluid in different viscometers and applied the analyses described in this paper, they found, in general, excellent agreement.

B. W. Shaffer, USA

2842. Tyabin, N. V., Motion of a sphere in a visco-plastic liquid dispersion system, Nat. Sci. Found. tr-17, June 1953; *Dokladi Akad. Nauk SSSR (N.S.)* **88,** 1, 57–60, 1953.

Stokes' equation does not apply to the motion of a sphere in liquid dispersion systems. Paper attempts to establish law of fall in such a medium by integrating the general equations of flow previously derived by author. It is shown that a disturbed zone arises around the moving sphere; this zone is assumed to take spherical form. If its radius is determined visually, the rheological constants of the system can be calculated.

B. Gross, Brazil

2843. Shank, M. E., Brittle failure of nonship steel-plate structures, *Mech. Engng., N. Y.* **76,** 1, 23–28, Jan. 1954.

Summary of a report to the Committee on Ship Structural Design, National Academy of Sciences-National Research Council. The complete report, entitled "A critical survey of brittle failure in carbon-plate steel structures other than ships," is about 30,000 words in length and is documented by an extensive bibliography. A slightly abridged version will appear in a forthcoming volume of papers presented at the ASTM-ASME symposium on Metallic Materials at Low Temperatures.

It was not the function of the survey to propose a remedy for brittle failure, or to evaluate techniques of fabrication and manufacture of nonship structures. The task at hand was to survey nonship brittle failures of carbon-plate steel structures and determine the factors of importance relating to such failures, in order to supplement the study of the failure of ships. It was shown that brittle failure results from a combination of many factors. Morever, there is at the present time no material readily available which would, if built into bridges, pressure vessels, and other nonship structures, totally prevent the occurrence of brittle fractures.

Finally, there is no known test which will surely predict from the behavior of small specimens the performance of a given steel in circumstances where structural brittle failure might occur. In short, careful design, selection of materials, and good workmanship are of the greatest importance in the prevention of brittle failure in nonship carbon-plate steel structures. This is also the case in ships. From author's summary

2844. Mironoff, N., A new method of micromechanic testing of metals. Localized tests of plasticity (in French), *Bull. tech. Suisse Rom.* **80,** 1, 3–12, Jan. 1954.

See AMR **5,** Rev. 2042.

2845. Ferguson, R. L., A further investigation of the effect of surface finish on fatigue properties at elevated temperatures, *NACA TN* 3142, 27 pp., Mar. 1954.

An investigation was conducted to evaluate the effects of surface roughness on fatigue properties of low-carbon N-155 alloy with a grain size of ASTM 6 and of S-816 alloy with a grain size of ASTM 6 to 7. Fatigue studies were conducted at 80, 1200, 1350, and 1500 F. In addition, an investigation of the effect of surface abrasion upon the nature, direction, magnitude, and depth of residual stresses and of the effect of time and temperature upon the relief of these stresses was conducted.

The stress-concentration effect of the surface roughnesses investigated was found to lower the fatigue strength of both N-155 and S-816 as much as 10% at the temperatures and times considered. This observation was made after the surface compressive stresses induced by roughening, which tend to increase fatigue strength, were reduced by annealing.

A study of strips roughened by abrasion showed that the abraded surface contains compressive stresses at right angles to the scratches and tensile stresses parallel to the scratches. These residual surface stresses may remain during fatigue cycling at low temperatures and, when of sufficient magnitude, act to appreciably increase fatigue strength. At elevated temperatures, however, these beneficial stresses were relieved during cyclic stressing and only the detrimental stress-concentration effects produced by abrasion remained and reduced fatigue strength.

From author's summary

2846. Stott, V. H., Aspects of research involving high temperatures, *Research, Lond.* **6,** 12, 454–457, Dec. 1953.

The main features peculiar to research involving temperatures above 1500 C are discussed. Simplicity and originality characterize most apparatus operating successfully at such temperatures.

From author's summary

2847. Fischer, W. A., Observations on creep properties of steel alloyed with zirconium at 500 C (in German), *Arch. Eisenhüttenw.* **24,** 9/10, 397–400, Sept./Oct. 1953.

There exists an essential difference in creep behavior of zirconium-alloyed steels due to the rate of zirconium and carbon percentage. This rate seems to have a critical value of 7.6. Steels ranking below this value show rather low creep resistance, some 12–15 kg/mm², but those ranking above the critical value have re-

sistance values of about 30 kg/mm². The creep values are obtained from short-time tests according to the DVM code. This higher resistance can be explained as a result from critical dispersion of Fe_3Zr_2. Moreover, steels ranking above the rate value 7.6 show a steplike time-strain curve when tested in long-time tests. It is assumed that this phenomenon depends on localized dispersion of Fe_3Zr_2. R. Nilson, Sweden

2848. **Hodge, P. G., Jr., On the plastic strains in slabs with cutouts,** *J. appl. Mech.* **20,** 2, 183–188, June 1953.

It is well known that a main weakness of plastic limit analysis is that, being effectively concerned with a hypothetical plastic-rigid material, it says nothing about the magnitude of deformations below the calculated yield point. At present these can generally only be guessed at, making what use is possible of the few available complete solutions for plastic-elastic solids, for instance, thick cylinders under pressure or thin tubes under bending and torsion.

Author contributes a further solution, namely, the expansion by external radial tension of a circular plate with a concentric hole. The material is incompressible, nonhardening, and follows the Tresca yield criterion and plastic potential. As was to be expected in this case, solution shows that the maximum local strain at the stage when the annulus first becomes fully plastic is only a few times the maximum strain at the elastic limit (except for very small holes where the situation is not entirely clear).

R. Hill, England

2849. **Hardrath, H. F., and Öhman, L., A study of elastic and plastic stress concentration factors due to notches and fillets in flat plates,** *NACA Rep.* 1117, 10 pp., 1953.

Supersedes paper reviewed in AMR **5,** Rev. 2299.

2850. **Sattler, K., Creep and shrinkage effects in prestressed concrete and composite steel-girder concrete-flange structures** (in German), *Beton u. Stahlbeton.* **49,** 1, 2; 8–13, 38–41, Jan., Feb. 1954.

An introductory note by the editor of the journal states that the paper forms an important contribution to stress analysis of prestressed-concrete structures since, besides exact solutions, simple approximate formulas for analyzing statically determinate and, in particular, redundant systems are given and illustrated by numerical examples.

Reviewer has been unable to follow paper, owing to host of symbols which are unfamiliar to him and not explained in paper. Moreover, repeated references for explanation of important statements or equations are made to author's 1953 book "Theory of composite structures" [Ernst, Berlin; in German], which will presumably also contain explanation of symbols. Readers not familiar with this book will have the same difficulties.

F. J. Plantema, Holland

2851. **Knittel, G., Influence of creep and shrinkage upon stress condition of prestressed-concrete members** (in German), *Bauingenieur* **29,** 1, 15–20, Jan. 1954.

Creep and shrinkage of concrete decrease prestress with time, and solution of this problem was previously obtained for single prestressing cable.

Author extends this work by standard method of analysis to any number of independent prestressing cables or wires and gives closed solution for two cables. Equations consider bending, shearing, and direct stresses in both pretensioned and posttensioned structural members. Results are illustrated by examples. Comparison with experimental evidence would have been useful to support analysis. G. G. Meyerhof, Canada

2852. **Washa, G. W., and Fluck, P. G., Effect of sustained overload on the strength and plastic flow of reinforced concrete beams,** *J. Amer. Concr. Inst.* **25,** 1, 65–72, Sept. 1953.

After completion of a three-year investigation into the influence of compression reinforcement on the plastic flow of reinforced-concrete beams (results of which were reported in title source, Oct. 1952, Proc. **49,** p. 89), 18 of the test beams were subjected to sustained overloads. Twelve of the beams contained compressive steel; however, in all cases the value of the sustained load used was selected at 85% of the ultimate load of companion control beams without compression steel. The beams with tensile steel only were designed as "balanced" sections in accordance with 1947 ACI Building Code; the remaining beams were identical to these, except for the addition of arbitrary amounts of compression steel. At the end of nine months the loads were increased to 90% of ultimate, and at ten months to 95%. At the end of 11 months the beams were loaded to failure.

Principal results were as follows:

(1) The deflection increase at the end of the overload period was 15 to 35% of the instantaneous deflection due to the overload. This compares with a plastic-flow deflection at the end of the earlier three-year period of 1 to $2\frac{1}{2}$ times the instantaneous deflection.

(2) The ultimate loads of the beams subjected to sustained overloads were nearly the same as those of the companion control beams tested at the start of the overload period.

Reviewer finds the above corroborates existing theories of reinforced-concrete beam behavior. It is not surprising that the high overloads caused neither unusually high plastic-flow strains nor reductions in strength, since in beams designed for ACI "balanced" design, the concrete stresses do not approach their ultimate values until the steel commences to yield.

H. Simpson, USA

Failure, Mechanics of Solid State

(See also Revs. 2765, 2847, 3050)

2853. **Brown, N., A quantitative measure of temper embrittlement,** *J. Metals* **6,** 3, 361–365, Mar. 1954.

The difference in tough-to-brittle transition temperatures between the embrittled and unembrittled states, determined by some type of notched-bar test, is usually taken as a measure for temper embrittlement. An objection is that this measure depends not only on material characteristics but also on the type of test. Author assumes that the embrittling treatment only affects the fracture criterion; i.e., the stress required to produce brittle fracture, and not the stress-strain curve. After this, from the theories of flow and fracture, he concludes that, in that case, the difference in reciprocals of the transition temperatures (°K) should be invariant with respect to the test method. His own experiments and an analysis of the experiments of others confirm this statement within the limits of experimental error.

J. H. van der Veen, Holland

2854. **Soete, W., Transverse strength and brittle fracture,** Conf. on Brittle Fracture in Steel, West of Scotland Iron and Steel Inst., Glasgow, Pap. no. 457, 18 pp., May 1953.

2855. **Hottenrott, E., Influence of prestressing and elastic characteristics on the fatigue life of bolt, nut assemblies** (in French), *Rech. aéro.* no. 36, 47–56, Nov.-Dec. 1953.

Author deals with the fatigue life of prestressed screw bolts in joints, especially those used in demountable construction elements of airplanes. Taking F_p as the prestressing force in the bolt, F_m

the static force, and F_a the amplitude of alternating forces, the force transmitted by the bolt is $F_1 = F_p + k(F_m + F_a \sin \omega t)$, that transmitted by the assembly elements is $F_2 = -F_p + (1 - k)(F_m + F_a \sin \omega t)$, k being a factor which depends on rigidity of bolt and assembly elements. Since k varies between 0 and 1, influence of alternating forces is reduced. Author derives a diagram consisting of three straight lines, obtaining a complete characteristic of $F_1 = f(F)$ and $F_2 = f(F)$ for a supposed preload F_p and a variable induced load F.

The factor k is carefully investigated, considering influences such as rigidity of male, female screw; screw thread; and flanges of assembly elements. Importance of experimental tests to control computations based on questionable assumptions is underlined and results of tests by author are presented.

Prestressing of bolts and choice of adequate rigidity of assembly elements would reduce weight and increase fatigue life of structure, and especially of bolts. H. Beer, Austria

2856. Bowman, C. E., and Dolan, T. J., Biaxial fatigue properties of pressure vessel steels, *Welding J.* **32,** 11, 529s–537s, Nov. 1953.

Paper reports an experimental investigation of relative fatigue properties of $^3/_4$-in. plates subjected to biaxial tension. Two types of steel specimens (A201 Grade "A" and A302 Grade "B") with and without stress raisers were used. A special hydraulic machine was designed and built for the tests. A.-t. Yu, USA

2857. Head, A. K., The growth of fatigue cracks, *Phil. Mag.* (7) **44,** 356, 925–938, Sept. 1953.

Qualitative features of the growth of fatigue cracks are discussed. A model is proposed which is made up of three types of mechanical elements, rigid-plastic, elastic, and shear elements, to account for the transfer of stress. Response of the model to alternating applications of stress is studied. Quantitative predictions from the model agree satisfactorily with experimental results. Author concludes that cracks may form very early, and that major part of fatigue test is growth of the crack.

N. M. Newmark, USA

2858. Bennek, H., Houdremont, E., and Mailander, R., Behavior of steels of different Charpy notch toughness during straining under multiaxial stresses (in German), *Arch. Eisenhüttenw.* **24,** 7/8, 315–321, July/Aug. 1953.

Object was to find out whether two steels, or two differently treated samples of the same steel, having different Charpy-impact transition curves without showing essential differences in the conventional tension test, would also behave differently in multiaxial static loading when no notches were used. The material for this investigation consisted principally of three quenched and tempered steels, viz., two Cr-Ni steels (0.9% Cr, 3.5% Ni) and one Cr-Si-Mn steel (1.1% Cr, 0.56% Si, 1.1% Mn). Each of these steels was tested in two conditons, viz., the temper brittle condition (furnace cooled after tempering) and the tough condition (water-quenched after tempering). The Charpy transition temperature of the brittle condition was approximately 150 C higher than that of the tough condition, whereas in room-temperature tension tests only a small difference was found, only with regard to reduction of area and true breaking strength.

After this, a series of tests was done under more severe conditions of multiaxial loading or temperature, but without using a notch. These were tension tests with larger cross sections, tension tests at lower temperatures, bend tests at different temperatures, biaxial tension or bulge tests on disks, biaxial testing of tubes by combined tension and internal pressure. It was found that the difference between tough and temper-brittle conditions became more apparent when the severity of the test conditions was increased. First, the appearance of the fracture of the temper-brittle specimen would change from fibrous into crystalline, the amount of strain up to the beginning of fracture remaining the same for both conditions; then, under more severe test conditions, the temper-brittle specimen would also show a lower strain. This is in agreement with general experience on brittle fracture. Finally, a comparison in fatigue tests showed that the endurance limits of the tough and temper-brittle conditions were the same. However, at loads above the endurance limit the temper-brittle specimens broke earlier than the tough specimens, obviously because the number of cycles between initial cracking and total rupture was less. J. H. van der Veen, Holland

Material Test Techniques

(See also Revs. 2853, 2856, 2858, 2882)

2859. Gifford, F. W., Creep tests on prestressing steel, *Mag. Concr. Res.* no. 14, 71–74, Dec. 1953.

Twenty wires of 0.2-in. diam and a length of 210 in. were stretched together in a frame. For calculating stress and relaxation of each wire by a triangle of forces, the center of the wire was deflected about $^1/_4$ inch by applying a dead load and measuring the deflection. The wires were tensioned at 50 to 90% of the ultimate strength; one wire being tensioned with the specified load, another being tensioned initially to a load 5% above this load for two minutes. For initial loads of 60% of the ultimate, the stress loss by relaxation at 420 days is 5% or less, the influence of overloading being small; but for higher stresses, the overloaded wires had a smaller relaxation than the wires without overloading.

A. Krisch, Germany

2860. Thum, A., and Richard, K., Results of creep experiments for low-alloy steels at 500 C with 100,000 hours duration (in German), *Schweiz. Arch.* **19,** 8, 235–245, Aug. 1953.

Results of creep tests can, just as fatigue tests, be represented in a diagram of stress vs. time. Creep results of 11 steels are given for 500 C on notched or unnotched specimens up to 100,000 hr. Influence of some components is given: Ni increases brittleness of Cr-Mo steels, Va increases brittleness of CR-Va, C and Si decrease brittleness. Consideration of equicohesion temperature is given.

Practical application requires test results of 10,000 hr and more. New concepts are proposed instead of the D.V.M. creep test used in Germany, viz.: (a) "Zeitstandfestigkeit," being creep strength after 10^3, 10^4, 10^5, or 10^6 hr; (b) "Zeitdehngrenze," being the stress giving a strain of 0.02%; 0.2%; 1% after 10^3, 10^4, 10^5 or 10^6 hours; and (c) damage function, determined by a classical tensile or impact test on material which has been submitted to a creep test.

Graphitization has practically not been observed in Germany; this is probably due to the use of Mo steel with a relatively high percentage of Cr. Intergranular cracks can be observed by optical microscope, transgranular cracks by electronic microcope. Regeneration of steels which give a large creep deformation is impossible. W. Soete, Belgium

2861. Bückle, H., Characteristic features and delimitation of the concept of Vickers microhardness (in French), *Rev. Métall.* 51, 1–12, Jan. 1954.

2862. Kohaut, A., Surface testing with the interference microscope (in German), *Werkstatt u. Betrieb.* **86,** 12, 725–731, Dec. 1953.

2863. **Peres, N. J. C., The geometry of the pyramidal indentation in the hardness testing of involute gear teeth,** *Austral. J. appl. Sci.* **4,** 3, 389–394, Sept. 1953.

Equations are developed for computing the area of the sides of the pyramidal indentation produced when the hardness of a cylindrical surface is tested by the Vickers method. Both orientations of the pyramid relative to the axis of the cylinder are considered. Equations are adapted to measuring gear-tooth hardness by assuming tooth surface is a cylinder of radius equal to radius of curvature of the involute at the point tested. Conclusion is that even for a small gear (approx. $2^1/_2$-in. pitch diam), discrepancy from a reading taken on a plane is only 2%.

D. K. Wright, Jr., USA

2864. **Mickevicz, E. J., Techniques and equipment for generation of dynamic high pressures,** *Trans. ASME* **75,** 3, 325–327, Apr. 1953.

Author describes the construction and functioning of a newly developed dynamic pressure-pulse generator that simulates in the laboratory the dynamic loading which ordnance items of a limited range of sizes might experience in service use. A preselected pressure pulse is obtained by burning the appropriate amount and type of propellant in a confined chamber. The magnitude, form, and duration of the pulse appear to be quite reproducible. A typical pulse has a peak pressure of 40,000 psi and a duration of 10 millisec. Apparatus has a relatively limited field of application.

J. S. Rinehart, USA

Mechanical Properties of Specific Materials

(See also Revs. 2819, 2845, 2846, 2847, 2856, 2858, 2859, 2987, 2994)

2865. **Huggins, M. W., Steel for prestressed concrete,** Canadian Conf. on Prestressed Concrete, 1954, University Extension, University of Toronto, E-1–E-16, 7 figs.

General review of the properties of steel as measured in the laboratory, with particular reference to prestressed concrete. Excellent as it is, paper would have gained by referring to British Code of Practice.

R. Quintal, Canada

2866. **Czyzewski, H., Mechanical aspect of seizing in metal wear,** *Trans. ASME* **76,** 3, 381–385, Apr. 1954.

Alloys of the class called "self-lubricated" alloys have a resistance to "accelerated mechanical abrasion" which it has not been possible to duplicate by external lubrication. Alloys in this class include gray cast iron (graphite lubricant), oil-impregnated powder-metal compositions (oil lead lubricant). Author's purpose is to present the mechanical aspect of seizing in metal wear which accounts in a qualitative manner for the observed phenomena in accelerated mechanical abrasion. The mechanical analysis also explains the failure of externally lubricated alloys to equal the performance of self-lubricated alloys.

From author's summary

2867. **Ritchings, F. A., and Crocker, S., Design of steam piping and valves for 1100 F,** *Trans. ASME* **76,** 2, 261–271, Feb. 1954.

Results are available for extended research on the behavior of austenitic and ferritic steels in a steam atmosphere at 1100 F. Allowable stresses at temperatures up to 1100 F and higher have been assigned by code committees with respect to long-time strength as determined from creep and stress-to-rupture tests. Two large boiler-turbine units employing austenitic piping for 1100 F throttle steam temperature are being installed in 1953. Austenitic steels are definitely expensive, however, and alloying elements, particularly nickel and columbium, are in short supply. The present paper reviews existing data and speculates on whether low-alloy-content ferritic steels could be made to serve the purpose. Spot comparisons are made of the relative cost of austenitic and ferritic steel pipe of equivalent carrying capacity.

From authors' summary

2868. **Koster, W., The Poisson modulus for metals** (in German), *Appl. sci. Res.* (*A*) **4,** 4, 329–336, 1954.

2869. **Greenberg, S. A., Steel for welded bridges and buildings,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 344, 9 pp., Nov. 1953.

2870. **Nathorst, H., Alloy steels. A survey given at the 4th International Mechanical Engineering Congress, June 5th, 1952,** *Metalen* **8,** 19, 20; 347–351, 363–367; Oct. 1953.

Reviewer considers this a concise and comprehensive summary of the fundamental factors to be considered in using the popular alloy steels. It contains a moderate bibliography.

W. H. Sparing, USA

2871. **Betteridge, W., The low-stress torsional creep properties of pure aluminum,** *J. Inst. Metals* **82,** 149–161, 1 fig., 1953–1954.

Kê [*Phys. Rev.* **71,** p. 533, 1947] has published results of investigations on anelastic properties of metals from which he deduced that some of the anelastic behavior was due to viscous flow at grain boundaries. Author was led to undertake present experiments by his disagreement with Kê's interpretation of those results.

Measurements of creep and creep recovery, using a high-sensitivity torsion method, were made upon 99.99% pure aluminum annealed, cold-rolled, and drawn into $^1/_4$-in. diam rods at a torque producing a maximum elastic shear strain of 2.8×10^{-5}. In this range, creep strain is said to be linearly proportional to stress (method is unsuitable at higher stresses). Results are analyzed by curve fitting. Creep strain is found to be proportional to a simple fractional power of time.

Rods grown as single crystals were also tested. They showed no creep under tensile load after 50 hr but a significant amount in torsion after 3 hr, although less than for the most highly annealed polycrystalline rod.

Results are interpreted as indicating that the mechanism of creep is the movement of dislocations existing in the crystal lattice before the test, and that it is not associated with viscous flow at grain boundaries. Reviewer wonders why, then, there is less creep in the single crystal rods than in the polycrystalline ones.

A. D. Topping, USA

2872. **Li, C. H., Washburn, J., and Parker, E. R., Variation of plastic properties with annealing procedure in zinc single crystals,** *J. Metals* **5,** 9, 1223–1225, Sept. 1953.

2873. **Young, R. B., and Mustard, J. N., Control of quality in prestressed construction,** Canadian Conf. on Prestressed Concrete, 1954, University Extension, University of Toronto, D-1—D-5.

Senior writer has been concrete consultant to the Hydro-Electric Power Commission of Ontario for many years, and approach to the concrete mix is thus very broad. Experience gained in other types of concrete structures is used. Unfortunately, specific problems such as various aspects of shrinkage and creep control are not detailed.

R. Quintal, Canada

2874. Bergström, S. G., Curing temperature, age and strength of concrete, *Mag. Concr. Res.* no. 14, 61–66, Dec. 1953. See AMR **7,** Rev. 1491.

2875. Meyerhof, G. G., The bearing capacity of concrete and rock, *Mag. Concr. Res.* no. 12, 107–116, Apr. 1953.

The internal friction theory of failure (Coulomb-Mohr) is applied to the stress conditions in bearing over a small area on massive blocks of concrete. Loading tests are reported on concrete blocks of a few inches in dimension, with load centrally applied to one face through a $1^1/_4$-in. diam steel footing. Splitting and punching shear failures occurred, with results in reasonable accord with the predicted strengths. H. A. Lepper, Jr., USA

2876. Heebink, B. G., Werren, F., and Mohaupt, A. A., Effect of certain fabricating variables on plastic laminates and plastic honeycomb sandwich construction, *For. Prod. Lab. Rep., U.S. Dept. Agric. Rep.* no. 1843, 15 pp., Nov. 1953.

The effects of fabrication pressure and curing process on the physical and mechanical properties of glass-cloth laminated plastics were studied. In general it was observed that the final resin content decreased with increased fabrication pressure, but the hardness, modulus of elasticity, and proportional limit increased with pressure. For various resins used in this investigation, curing time was reduced as temperature increased. For plastic honeycomb-sandwich materials, it was concluded that laminate facings were preferably premolded except for the one inner ply. L. W. Hu, USA

2877. Bartenev, G. M., and Novikov, V. I., On the modulus of rubber under static compression (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **91,** 5, 1027–1030, Aug. 1953.

Authors extend previous concepts [AMR **6,** Rev. 1917] to specimens under practical conditions, in nonuniform compression. They define a "static" modulus E', the ratio of mean stress to mean strain; E' is characteristic of the specimen, whereas the E previously defined is characteristic of the material. They establish an empirical relation $E' = E(1 + a\Phi)$: Φ is the ratio of the cross-sectional area to area of lateral surface; a is 1.0 when the contacts with the rigid compressing surfaces are dry, 0.2 when they are lubricated. William Fuller Brown, Jr., USA

2878. de Baare, J., Some properties and applications of silicone rubber (in Dutch), *Ingenieur* **66,** 4, Ch. 5–Ch. 8, Jan. 1954.

After a brief description of the development of organic silicone compounds and the chemical structure of silicone rubber, a survey is given of its physical and chemical properties. The thermal stability, oil resistance, low temperature flexibility, and ozone resistance are the most important properties, and they have given a growing number of applications to this inorganic based elastomer in such cases where normal organic rubbers fail.

From author's summary

2879. Clark, J. F., and Preston, J. M., Thermoelastic properties of synthetic fibres, *J. Text. Inst., Trans.* **44,** 12, T596–T608, Dec. 1953.

Vinyon, Vinyon N, nylon, and Terylene fibers held (a) at constant load by means of a chainomatic device, (b) at constant length by means of a balance, were submitted to different temperatures in order to verify if typical fiber-forming substances should show rubberlike properties at raised temperatures.

In case (a) the changes in length were measured by a cathetometer; in case (b) the changes in load were measured by the weights necessary to keep the balance pointer at zero. The apparatus and the methods are described. The reproducibility is examined.

Contraction-temperature curves under different loads and tension-temperature results for different elongations are given. The latter curves show that the experimented fibers acquire rubberlike properties at raised temperatures. In these temperature ranges, the values of the energy and entropy functions are calculated and the plot of the tension against the elongation shows typical rubberlike stress-strain curves.

D. De Meulemeester, Belgium

2880. Bright, N. F. H., Carson, T., and Duff, G. M., The heat of wetting of fibres, *J. Text. Inst. Trans.* **44,** 12, T587–T594, Dec. 1953.

Measurements have been made of the total heats of wetting of wool, Ardil, natural and regenerated silk, drawn and undrawn nylon, drawn and undrawn Terylene, drawn continuous filament orlon, and also of the partial heats of wetting of wool and Ardil.

From authors' summary

2881. Catsiff, E., Alfrey, T., Jr., and O'Shaughnessy, M. T., Generalized creep curves for nylon, *Textile Res. J.* **23,** 11, 808–820, Nov. 1953.

Mechanics of Forming and Cutting

(See also Revs. 2765, 2840, 2845)

2882. Siebel, E., Hot working of metals (in German), *Z. Metallk.* **45,** 1, 1–7, Jan. 1945.

Author surveys scientific reports on cold and hot forming of metals, including extrusions and castings. Basic laws of plasticity and temperature effects are presented and correlated. Working of light alloys and their characteristics are also discussed. A. O. Schmidt, USA

2883. Halliday, W. M., Faults in pressure die castings – I, *Metallurgia Manchr.* **49,** 291, 21–25, Jan. 1954.

2884. Krishnan, R. M., Khanna, M. N., and Nijhawan, B. R., Moulding sands for piston ring castings, *J. sci. indust. Res. India* **12,** 9, 417–421, Sept. 1953.

2885. Cook, M., and Parker, R. J., The computation of loads in metal strip rolling by methods involving the use of dimensional analysis, *J. Inst. Metals* **82,** 129–140, 1953–1954.

The major value of this paper comprises a presentation of experimental data for the separating force during rolling of soft copper strip which extends to high reductions (up to 80%) and also very high ratios of roll diameter to initial thickness (up to 860). This makes the information the most complete from which the effect of roll flattening could be evaluated for a wide range of rolling conditions. The objective of the authors was to show that the separating force for several subsequent passes can be calculated from a few measurements for increasing reductions. The analysis is based on the elementary equation for the pressure required to compress a slab, which has also been used successfully by R. Hill and I. M. Longman [*Sheet Metal Ind.* **28,** p. 705, 1952] and others to determine the separating force in rolling and the limits of rolling. However, authors neglect the effects of roll flattening and calculate the constants in the equation, including the friction coefficient from the test data. While the authors' method may be suitable for practical purposes, its physical significance appears rather obscure G. Sachs, USA

2886. **Welsh, A. F., Capacities and sizes of equipment in accumulator stations for heavy-press operation,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-128, 11 pp.

2887. **Majors, H., Jr., Preliminary investigation on the effect of sequence on cold-drawing cylindrical steel rods through dies—Part I,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-73, 17 pp.

2888. **Majors, H., Jr., Effect of sequence on cold-drawing 2S-O aluminum rods through dies—Part II,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-74, 13 pp.

2889. **Kienzle, O., Force and velocity measurements for pressing machinery** (in German), *Werkstattstech. Maschinenb.* 43, 12, 553–560, Dec. 1953.

Design of a number of measuring devices. Those for forces and torsion moments make use of strain gages. Those for linear and angular velocities make use of interrupted light signals thrown on a photocell, the frequency of the interruption being a measure of the velocity. C. Zwikker, Holland

2890. **Towler, F. H., and Towler, J. M., Control valves for direct-hydraulic presses,** *Instn. mech. Engrs. Proc. (B)* **1B,** 9, 420–436, 1952–1953.

Some direct-hydraulic presses have become very complicated owing to the introduction of servoelectric controls, embodying a mass of electrical gadgets, solenoids, microswitches, etc. In this paper a new completely hydraulic control system is described which entirely replaces the electrical controls, thereby bringing all maintenance problems within the scope of the hydraulic engineer. Also, with the elimination of electrical delays it is possible to insure almost instantaneous valve action. The paper deals briefly with packingless piston valves, the avoidance of various forms of lock, and the problems involved in the design, construction, and control of large hydraulic presses, the choice of the most advantageous working pressure, and the viscosity of the hydraulic oil.

A detailed description is given of a 1000-ton direct-hydraulic forging and planishing press, powered by high-speed pumps totaling 665 pump hp and controlled by a single-lever, completely hydraulic, remote-control panel. This press makes reversal in $^{1}/_{10}$ sec, making short planishing strokes as lively as a pneumatic hammer. In conclusion, controls and multiple power units for much larger presses are discussed. From authors' summary

2891. **Harding, H. V., Matulaitis, V. E., and Stoke, R. C., Electrical-discharge machining,** *Amer. Mach.* **98,** 6, 137–148, Mar. 1954.

Not a complicated process, electrical-discharge machining is a series of discharges occurring between a tool or electrode, shaped to the desired dimensions of the hole or cut desired, and the work. The rate of discharge varies between 20,000 and millions per second. It can be maintained at any predetermined setting to give the desired cutting speed, accuracy, and finish.

From authors' summary

2892. **Burtow, A. J., New computing method for adjusting an inside grinding machine for grinding the convex contact surface of bearings** (in German), *Maschinenbau-Technik,* 2, 11, 512–516, Nov. 1953.

Article presents ways and means of grinding hyperbolic and near-hyperbolic inside surfaces for ball-bearing races. The geometry is similar to that used in grinding the exterior surfaces of straightening rolls and exterior races. The proper curve shape is obtained by setting the grinding wheel at a proper angle with the axis of the ball race. By this method it is possible to grind extremely hard races to a very smooth finish.

R. G. Sturm, USA

2893. **Hardwick, W. R., Grinding hazards,** *Metallurgia, Manchr.* **49,** 291, 21–25, Jan. 1954.

The grinding of tools is accompanied by local heat generation, and unless the operation is carried out correctly it can result in softening and cracking of the surface of the tool. These effects may be aggravated by incorrect heat-treatment prior to grinding.

From author's summary

2894. **Oxford, C. J., Jr., On the drilling of metals. Part I: Basic mechanics of the process,** ASME Ann. Meet., N. Y., Dec. 1953. Pap. 53—A-167, 17 pp.

Main contribution in this paper is a clear analytic presentation of how the effective rake angle varies along the cutting edge of a drill. Despite the millions of drills in everyday use, the geometric complexities have deterred previous investigators from giving a rigorous solution. Good pictures of drill chip formation are difficult to take, but the author here presents the best photographs this reviewer has ever seen.

Extracts from this paper have appeared in the May 1954 issue of *Tool Engineer* (p. 145) and the March 1 issue of *American Machinist* (p. 102). E. G. Loewen, USA

2895. **Levesque, G. N., Testing methods for production of accurate machine slideways,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-69, 9 pp.

2896. **Gilbert, W. W., Boston, O. W., and Siekmann, H. J., Cutter life for face-milling cast iron,** *Trans. ASME* **76,** 4, 607–612, May 1954.

Face-milling tests on cast irons are recorded, using carbide, high-speed steel, and cast nonferrous cutters. Tool life was measured in relation to feed, depth, and width of cut, cutting speed, and number of cutter teeth. Nomograph, based on results, is included for calculating cutting conditions.

R. N. Arnold, Scotland

2897. **Beutel, H., Solid joints between sintered carbides and steel in tools** (in German), *Werkstattech. Maschinenb.* **43,** 12, 560–566, Dec. 1953.

Paper discusses brazing processes with various brazing alloys for metal-cutting tools with carbide tips and strength properties of joints obtainable; glues for carbide tips and their possibilities of application; shrinking, forging, and pressing of carbide inserts into steel holder; mechanical clamping of carbide tips.

A. O. Schmidt, USA

Hydraulics; Cavitation; Transport

(See also Rev. 2734)

2898. **Streck, O., Elements of water control and hydrology [Grundlagen der Wasserwirtschaft und Gewässerkunde],** Berlin, Springer-Verlag, 1953, x + 466 pp., 291 figs. DM 43.40.

Author, well known for his important books on problems in hydraulic engineering, presents interesting data on applied hydrology. List of subjects analyzed in the book is very extensive: (1) Aims and tasks of water control: water resources, uses of water, damage protection. Examples of water control in

Ruhr, Silesia, Upper Rhine power development, Colorado River problems. (2) Weather and meteorological elements, types of climate. (3) Elements of water regime: rainfall, runoff, infiltration, evaporation. (4) Properties of surface waters: valleys, river bed; survey and mapping. (5) Water stages and discharges: observations and computations. (6) Terms and units of water control; power development without storage and with storage. (7) Floods, ice cover; water-stage forecasting. (8) Sediment movements in rivers: silt and bed-load measurements. (9) Underground water: origin, investigations, observations. (10) Seacoast: properties of salt water; wind and waves action; tides, sea currents. (11) Biological aspects: quality of water, life in water, nature conservation.

Excellent examples and figures make the book very interesting for every hydraulic engineer. S. Kolupaila, USA

2899. Morris, H. N., A new concept of flow in rough conduits, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 390, 31 pp., Jan. 1954.

Using a rather simplified physical picture of flow over hydraulically rough surfaces, author proposes that friction factors for rough pipes and channels can be more or less uniquely determined on the basis of three flow types: "Isolated-roughness flow," in which the roughness elements are so spaced that the wake of any one element does not affect adjacent ones; "wake-interference flow," in which there is interaction between adjacent wakes; and "quasi-smooth" or "skimming" flow, in which the flow "skims over the crests of the roughness elements, with stable vortexes in the grooves between the elements." Assuming logarithmic velocity distribution, formulas for friction factors embodying the postulated behaviors of these factors for each flow type are given, the constants being evaluated by means of data for pipes with uniform roughness. P. Eisenberg, USA

2900. Talbot, L., Laminar swirling pipe flow, *J. appl. Mech.* **21,** 1, 1–7, Mar. 1954.

The problem of the decay of a rotationally symmetric steady swirl superimposed on Poiseuille flow in a round pipe is investigated theoretically and experimentally. The object is to determine the degree to which the rate of decay of the swirl as predicted by a linearized theory agrees with measured rates of decay at flow conditions near the critical conditions for swirl instability. The solution to the linearized equation of motion for the swirl is obtained. Swirling flow was produced experimentally by rotating a section of the test pipe. Swirl velocities are determined from motion-picture studies of colored oil droplets introduced in the flow. The stability of the swirl is investigated through visualization of a dye filament, and a critical curve for swirl instability is determined experimentally, relating the angular velocity of the rotating section to the Reynolds number. The theoretical and experimental values for the decay parameter are found to agree closely, even at conditions of flow near the critical conditions for instability. It is concluded that, in the problem under consideration, the nonlinear effects are not appreciable for stable decay of the swirl. G. W. Morgan, USA

2901. Szablewski, W., Inlet conditions in tubes with turbulent flow (in German), *Ing.-Arch.* **21,** 5/6, 323–330, 1953.

The turbulent inlet flow of a tube is analyzed theoretically. The velocity profile of the boundary layer is approximated by the logarithmic velocity law. The empirical coefficients of this law are taken from the theory of fully developed flow in a tube. The flow in the core is treated as a potential flow. The following quantities are calculated: local pressure loss, total pressure loss, and the wall friction. Also given are the lengths of the core and the velocity distributions at the inlet. The results are given for Reynolds numbers (based on tube diameter) of 10^5, 5×10^5, 10^6, 5×10^6.

From author's summary by H. P. Liepman, USA

2902. Yassin, A. M., Mean roughness coefficient in open channels with different roughnesses of bed and side walls, ETH, Zürich, Mitt. Versuchsanst. Wasserb. u. Erdb. no. 27, 90 pp., 1953; Zürich, Verlag Leeman.

Basic part of paper is description of series of tests on rectangular laboratory channels of widths the order of depth of flow. Three channels are studied with different width/depth ratios and for each, three series of tests are run: smooth sides and bottom, sides and bottom roughened, and smooth sides with bottom roughened. All experimental measurements are presented. Author then attempts to check three equations linking effects of sides and bottom in defining Darcy friction factor or Strickler roughness coefficient. He concludes that both the equation of Einstein [*Schweiz. Bauztg.* **103,** 8, 1934] and one derived by summing the friction factor of each part multiplied by the relative wetted perimeter are accurate enough for field purposes. In last part of paper the concept of hydraulic radius is examined in detail by computing shear distribution around wetted perimeter. For computations, author assumes Prandtl velocity distribution. He concludes that hydraulic radius is not the best concept because shear on bottom and sides has different values.

Reviewer believes that paper would be of greater value had some of modern boundary-layer methods been used in analysis of data. Also, more attention to relative roughness might have yielded more usable results. W. D. Baines, Canada

2903. Dodson, C. R., Goodwill, D., and Mayer, E. H., Application of laboratory PVT data to reservoir engineering problems, *J. Petr. Technol.* **5,** 12, 287–298, Dec. 1953.

Brief résumé is given of development and application of pressure-volume-temperature analyses of reservoir fluids to petroleum reservoir engineering problems. Necessity of obtaining accurate reservoir pressure and temperature information and the importance of representative samples of reservoir fluid are indicated. Types of gas liberation and application of data obtained from these liberations are discussed. Laboratory methods of obtaining flash, differential, and composite gas liberation data are briefly discussed. Requirements of laboratory PVT determinations are given for the "ideal," "minimum," and "no reservoir sample" cases. Good bibliography is provided by 50 literature references.

S. R. Faris, USA

Incompressible Flow: Laminar; Viscous

(See Revs. 2763, 2914, 2958, 2965, 3000, 3033)

Compressible Flow, Gas Dynamics

(See also Revs. 2734, 2921, 2922, 2925, 2926, 2958, 3001, 3013, 3026, 3027, 3043, 3045)

2904. Cabannes, H., Influence of accelerations upon the curvature of shock waves. Parts I, II (in French), *C. R. Acad. Sci. Paris* **238,** 3, 4; 321–323, 448–449, Jan. 1954.

Flow in the neighborhood of the nose of a sharp-pointed obstacle in accelerated translational motion at supersonic speeds, with attached shock wave, is analyzed. Part I deals with bodies of revolution and part II with plane bodies. The values of the velocity components, pressure, and density at the nose being determined by the initial data relating to the body, the first

derivatives of these quantities, together with the velocity and acceleration of the nose, are found from the shock equations, surface boundary condition, and equation of motion. The ratio of the radius of curvature of the shock to that of the obstacle at the nose can then be expressed as a linear function of the acceleration with coefficients depending on the Mach number and nose angle of the obstacle. It follows that knowledge of the curvature at the apex of the shock suffices to determine the acceleration, and, hence, the total resistance of the obstacle.

Maurice Holt, England

2905. **Öhman, L., An experimental method of determining the drag of a shock wave with application to a ducted body,** *Flygtekn. Försöksanst. Medd.* **51,** 21 pp., Jan. 1954.

The problem discussed is that of determining from experiments the drag due to the head shock wave of an axisymmetric body. The theory follows Liepmann [AMR **5,** Rev. 1151] and certain diagrams are included to facilitate the calculation. The method is based on knowledge, e.g., from schlieren photos, of the shock-wave shape. For the infinite outer part of the shock wave, an approximate expression is worked out, based on Whitham's theory [AMR **4,** Rev. 1245; **6,** Rev. 961]. The application of these methods to a ducted body at various inlet mass-flow conditions is carried out. The effects of small errors in experimental determination of Mach number and shock angle are investigated.

W. R. Sears, USA

2906. **Broer, L. J. F., and van Den Bergen, A. C., On the theory of shock structure II,** *Appl. sci. Res.* (*A*) **4,** 3, 157–170, 1954.

In part I [AMR **6,** Rev. 2295], first author considered shock profile as determined by viscosity and heat conduction, including Burnett terms in equations. Present paper is confined to Navier-Stokes terms and adds the effect of relaxational broadening due to lag in rotational energy of molecules of the gas. This introduces one more variable, the rotational temperature, and one additional equation. Problem is reduced to one nonlinear differential equation which is integrated approximately for a Prandtl number of 3/4. Curves plotted show considerable broadening of shock wave due to relaxation. R. E. Street, USA

2907. **Meksyn, D., Integration of the equations of transonic flow in two dimensions,** *Proc. roy. Soc. Lond.* (*A*) **220,** 1141, 239–254, Nov. 1953.

An approximate method for solutions near $M = 1$ is introduced by using the equipotential lines (α = const) and the streamlines (β = const) of the related incompressible flow as coordinates. It is argued that $\partial\varphi/\partial\beta$ may be disregarded and $\partial\varphi/\partial\alpha$ considered a constant for differentiation and integration. The resulting equations are nonlinear Poisson equations but may be solved by an iteration method. A criterion for the appearance of shocks is established. In applying the method to the flow past a circular cylinder and to a flow considered by Kaplan [*NACA TR* 768], good agreement is found with previous calculations.

H. G. Cohen, USA

2908. **Wilder, J. G., Jr., and Hindersinn, K., Spreading of supersonic jets in supersonic streams,** *Aero. Engng. Rev.* **12,** 10, 54–68, Oct. 1953.

Paper presents results of comprehensive tests to provide basis for determining possibility of scavenging exhaust gases from jet engines operating in supersonic wind tunnels.

By means of Pai's theory [AMR **2,** Rev. 2707], transformed for use with total temperatures and simplified, authors develop equation for predicting jet spread. Experiments show good correlation with the Pai theory, using experimentally determined hypothetical starting point for stream mixing. Care must be used in applying resulting curves to other wind tunnels, since distance to hypothetical starting point of mixing may vary with turbulence level, Reynolds number, and primary nozzle-wall heat-transfer coefficient.

Studies of jet spreading through shocks, both normal and oblique, are presented with the aid of schlieren pictures. Normal shock case appears to be covered rather completely, while the oblique case appears to be in preliminary stage.

Further curves illustrate spread angles of jets tested in supersonic streams, as well as jet boundary displacement due to under- or overexpanded jets.

Some information, mainly qualitative, is presented on effects of thick wakes on jet mixing and on effects of inclined jets on jet displacement and mixing.

On the whole, paper is a very complete coverage of subject, with many general conclusions valuable to designers of wind tunnels utilized in tests of operating jet engines.

H. L. Bloom, USA

2909. **Martin, M. H., and Thickstun, W. R., An example of transonic flow for the Tricomi gas,** "Fluid Dynamics," Proc. Symp. app. Math., vol. IV; New York, McGraw-Hill Book Co., Inc., 61–73, 1953.

For the study of transonic flow of a polytropic gas, Frankl has employed the equation

$$\psi_{\sigma\sigma} + K(\sigma)\psi_{\theta\theta} = 0$$

where σ is a variable used in place of the pressure p and defined as the integral of q^{-2} with respect to p. $K(\sigma)$ is $-q^3 q_{pp}$. Various authors have proposed Tricomi's equation as an approximation in which $K(\sigma) = \sigma$. This equation has a particular solution defined by

$$\psi^3 + 3\sigma\psi = 3\theta$$

Authors obtain this solution by a new method and discuss in detail the flow in the hodograph and physical planes. The flow, as defined by the solution when drawn in the physical plane, has a similarity to a Cornu spiral. R. C. Knight, England

Turbulence, Boundary Layer, etc.

(See also Revs. 2901, 2928, 3001, 3004, 3014, 3016, 3017, 3043)

2910. **Bernard, J.-J., Some results and classical methods of study of turbulent flow** (in French), Colloquium, AGARD, Cambridge Univ., Dec. 7–11, 1953; "Selected combustion problems, fundamentals and aeronautical applications," London, Butterworths Publications, Ltd., 1954, viii + 534 pp., 195–214.

The classical researches, which were directed toward practical applications, attempt the determination of the mean motion and the corrections which must be introduced into the usual equations of aerodynamics in order to account, in more or less empirical fashion, for the secondary effects connected with velocity fluctuations. Application of these calculations to the study of certain flows permits coordination of experimental results and seems capable of generalization to combustion phenomena. The modern developments of the theory of turbulence, which require a mathematical formulation which is often complicated, describe with precision the appearance, evolution, and the decay of turbulence, as well as the correlations which exist between the phenomena which are observed at two points or at two different instants of time. The studies lead to results which are less di-

rectly usable, but some of which have, nevertheless, received experimental verification.

From author's summary by P. Laffitte, France

2911. Weltmann, Ruth N., and Kuhns, P. W., Density profiles of subsonic boundary layers on a flat plate determined by x-ray and pressure measurements, *NACA TN* 3098, 30 pp., Feb. 1954.

Authors present boundary-layer density profiles for laminar, transitional, and turbulent boundary layers at Mach numbers of 0.55 and 0.78 and at Reynolds numbers from 0.2×10^6 to 2.9×10^6. Interferometer data are included in some cases. Assumptions required to reduce the pressure and radiation data to density profiles are discussed.

Considerably larger experimental scatter resulted from the x-ray data than from either the total pressure or interferometer data; however, the density profiles from the total pressure and interferometer data did not agree by a magnitude of the order of the scatter in x-ray data. The largest difference in density ratio (ratio of local to free-stream density) between the pressure and radiation methods is approximately 0.8%, whereas the largest change in density ratio through any of the boundary layers is only about 8%. Authors conclude: "As an experimental method, the total-pressure-probe method has definite advantages over the x-ray radiation method." However, since the sensitivity of the x-ray method is proportional to the cube of the wave length, the reviewer believes the x-ray radiation method would have yielded more accurate density profiles if "softer" x rays (average wave lengths from 5 to 6 angstroms rather than 3 to 4 angstroms) had been used. G. J. Nothwang, USA

2912. Torda, T. P., Boundary layer control by distributed surface suction or injection. Bi-parametric general solution, *J. Math. Phys.* **32,** 4, 312–314, Jan. 1954.

Author describes briefly a method for analyzing boundary-layer control by distributed surface suction or injection. Both the momentum and the energy integrals are used. The complete analysis will be published after an evaluation of method is made by checking the theoretically predicted values against experiments. C. C. Lin, USA

2913. Burgers, J. M., and Mitchner, M., On homogeneous nonisotropic turbulence connected with a mean velocity gradient. I, II, *Proc. k. Ned. Akad. Wet.* (*B*) **56,** 3, 4; 228–235, 343–354, May/June, Sept./Oct. 1953.

The statistical theory of turbulence in the absence of a mean flow is generalized to include a constant velocity gradient. In the first part of the paper, the basic equations are derived both in the correlation form and in the spectral form. It is possible that, in an unlimited field with a constant velocity gradient, the length scale of the turbulence would become infinite, so that the spectrum might be divergent at the lower end. No clear indication of such behavior was obtained from the equations.

Part II of this paper deals with steady shear flow. By introducing Heisenberg's formula for the transfer function, the spectrum at large wave numbers is found to be of the form

$$E(k) = Ck^{-5/3}[1 + (k/k_s)^4]^{-4/3}$$

where k is the wave number and C and k_s are constants of integration, which are determined in terms of certain physical quantities.

Finally, a brief discussion is given for the case of nonhomogeneous turbulence.

[Reviewer's remark: Similar work has been done by Flavio B. Reis in his Ph.D. thesis at M.I.T., January 1952 (unpublished). Reis also demonstrated the permanence of the large eddies in the presence of a velocity gradient, assuming that the spectrum does not become divergent at the lower end. He also obtained the above formula for the spectrum by similar methods and gave similar discussions of the physical interpretation of the constants.] C. C. Lin, USA

2914. Schuh, H., Calculation of unsteady boundary layers in two-dimensional laminar flow, *Z. Flugwiss.* **1,** 5, 122–131, Oct. 1953.

Author attacks problem using a generalization of the Pohlhausen method for incompressible flow. Most of the examples presented are solved in two ways, using the momentum integral and the energy integral. The Pohlhausen and Hartree velocity profiles are used.

Two special cases of unsteady boundary layer on an infinite plate are solved and good agreement with exact solutions is shown. Boundary-layer growth near fore and aft stagnation points is also discussed.

In the general case when the pressure gradient is an arbitrary function of space and time, it is shown that the problem may be reduced to the solution of two ordinary differential equations. This formulation is used in finding the boundary-layer growth on a circular cylinder starting impulsively from rest. Unsteady boundary layers on finite flat plates at zero incidence are treated in some detail.

Method appears to be relatively easy to apply and author states that method may be generalized to the compressible case. R. C. Roberts, USA

2915. Carrier, G. F., Boundary layer problems in applied mechanics, Advances in appl. Mech. **III,** 1–19, 1953. [Academic Press, Inc., N. Y.]

Several isolated physical problems formulated as boundary-value problems for certain differential equations are analyzed. The similarity to the boundary-layer methods of analysis used in fluid dynamics is shown. Instead of obtaining a rigorous solution of the differential equation, one solves approximate forms of the equation valid in appropriate domains. The limitations in the application of this method depend largely on the problems, whose physical descriptions follow.

(a) In the ocean-current problem, the turbulent motion on a rotating sphere of fluid is considered. It is assumed that the stress transmitted to the waves is proportional to the wind intensity. The velocity vector is assumed to lie always in a spherical surface.

(b) In the heat-transfer problem, small pellets are calendered between two rolls where they behave like an incompressible viscous fluid. The problem is to find the temperature distribution due to heat dissipation at high rotation speeds of the rolls.

(c) In the convection problem, one studies the gas motion and heat-transfer rate in an infinite cylindrical container whose surface temperature distribution is given by $T = T_0(1 + A \cos \theta)$.

(d) In the relaxation oscillations of the Van der Pol oscillator, one studies the periodic solution of $\epsilon y'' - (1 - y)^2 y' + y = 0$ for small ϵ.

The main purpose of the paper is not to solve these physical problems, but rather to show the potentialities of the boundary-layer analysis. F. N. Frenkiel, USA

2916. Zatt, J. A., Calculation of the temperature yield for incompressible laminar boundary-layer flow with and without pressure gradient, *Nat. LuchtLab. Amsterdam Rap.* no. 130, 47 pp., 1953.

The two-dimensional incompressible laminar boundary layer

is calculated for flow along a flat plate with and without pressure gradient and for a cylinder with constant wall temperature from the momentum and integrated heat equations. The velocity and temperature profiles are assumed to belong to one-parameter families and are derived with and without heat transfer at the wall. Agreement between the calculated and measured results is very satisfactory. Equations, tables, and curves present the results concisely. C. F. Bonilla, USA

2917. **Moore, F. K., Displacement effect of a three-dimensional boundary layer,** *NACA Rep.* 1124, 5 pp., 1953.

Supersedes article reviewed in AMR **6,** Rev. 205.

Aerodynamics of Flight; Wind Forces

(See also Revs. 2937, 2949, 2979)

2918. **Gates, O. B., Jr., and Woodling, C. H., A method for estimating variations in the roots of the lateral-stability quartic due to changes in mass and aerodynamic parameters of an airplane,** *NACA TN* 3134, 66 pp., Jan. 1954.

The inability to predict changes in dynamic response of an aircraft due to changes in its mass and aerodynamic parameters, without resorting to direct solution of the stability quartic, has long been an irksome deficiency in the engineer's supply of theoretical techniques. In this paper a method is derived for predicting changes in the lateral dynamic response of an airplane within the range in which these changes are close to being linear functions of the parameter increments. Applications of the method indicate that satisfactory results could be obtained well beyond this range. Reference is made to a similar analysis by K. Mitchell [AMR **3,** Rev. 1353], which considers the longitudinal—as well as the lateral—stability quartic. A. L. Jones, USA

2919. **Michael, W. H., Jr., Investigation of mutual interference effects of several vertical-tail-fuselage configurations in sideslip,** *NACA TN* 3135, 35 pp., Jan. 1954.

Before vertical-tail design becomes a science, more data and theory are required of mutual interference effects between relevant aircraft components. Note supplies useful experimental data for nine unswept vertical tails on three circular section fuselages—effectiveness of vertical tail for directional stability, vertical and longitudinal centers of pressure.

Effectiveness of vertical tail was increased by mutual interference, which was greatest for small ratios of span to fuselage diameter and large aspect ratios of the vertical tail; in some cases, increases as large as 100% of the tail-alone-effectiveness were measured. The length, longitudinal position of tail on, and incidence of, the fuselage were secondary parameters.

Longitudinal center of pressure remained near tail quarter chord, but vertical center of pressure moved toward fuselage as ratio of tail span to fuselage diameter was reduced.

J. M. Evans, Australia

2920. **Kelly, H. R., The prediction of nonlinear normal force and pitching moment for bodies of revolution without boat-tail,** *J. aero. Sci.* **20,** 12, 854–855, Dec. 1953.

Paper presents a method of estimating the viscous effects on the normal-force distribution for inclined bodies. The method is based upon an assumed equivalence between the experimentally determined variation with time or with distance traveled of the drag coefficient of a circular cylinder impulsively set in motion from rest, and the axial variation of the cross-flow drag coefficient for the inclined body. The method is a modification of that originally proposed by H. J. Allen in a classified NACA publication and is intended to account for the effects on the normal-force distribution of the axial development of the viscous cross flow. Studies of the applicability of this method performed by the reviewer show that it is best suited to the estimate of the characteristics of low fineness ratio bodies, but grossly overestimates the normal force and pitching moment for high fineness ratio bodies at large angles of attack. E. W. Perkins, USA

2921. **Stivers, L. S., Jr., The effectiveness at high subsonic Mach numbers of a 20-percent-chord plain trailing-edge flap on the NACA 65-210 airfoil section,** *NACA TN* 3127, 15 pp., Mar. 1954.

An analysis has been made of the effectiveness of a 20-percent-chord plain trailing-edge flap on the NACA 65-210 airfoil section from section lift-coefficient data obtained at Mach numbers from 0.30 to 0.875. The analysis also includes a comparison of the effectiveness of this flap with that of a spoiler and a dive-recovery flap on the same airfoil section. From author's summary

2922. **Axelson, J. A., and Stevens, G. L., Investigation of a slat in several different positions on an NACA 64A010 airfoil for a wide range of subsonic Mach numbers,** *NACA TN* 3129, 35 pp., Mar. 1954.

An investigation of the two-dimensional aerodynamic characteristics of an NACA 64A010 airfoil with a slat has been conducted in the Mach number range from 0.25 to 0.85, with a corresponding Reynolds number range from 3.4 million to 8.1 million. Two families of slat positions were investigated, one with the slat leading edge extended forward along the airfoil chord line, and the other with the slat extended forward and displaced below the chord line. From authors' summary

2923. **Marini, M., Aerodynamic forces on sweptback wings in oscillatory motion** (in Italian), *Aerotecnica* **33,** 4, 275–287, Aug. 1953.

Aerodynamic forces on thin oscillating sweptback wings of considerable aspect ratio in uniform translatory motion through an incompressible fluid can be determined if the vortex distribution of the corresponding sheet of bound vortexes is known. The distribution of vortexes over the wing chord is assumed to have the same form as that given by P. Cicala [*Aerotecnica* **18,** 1, 1938] for wings of infinite aspect ratio. Paper gives all steps in the derivation of expressions of the induced velocity and some indications on the determination of the distribution of bound vortexes. The logarithmic singularity in the expression of induced velocity in the axis of symmetry due to bound vortexes can be suppressed by introducing a corrective vortex distribution of appropriate form. The formula for the induced velocity of the trailing vortex sheet is derived without simplifications. The expression for the resultant induced velocity consists of an expression for the velocity of the two-dimensional case and of a sum of terms containing only one component g_0 of the total vorticity.

Many results are given in such a form that existing tables can be used when calculating terms with higher functions.

A. Kuhelj, Yugoslavia

2924. **Hasegawa, M., On the slow viscous flow past thin symmetrical Joukowsky airfoils—The solution of Oseen's equation** (in Japanese), *Trans. Soc. mech. Engrs. Japan* **19,** 85, 21–26, Sept. 1953.

A method of solving Oseen's equation for the slow motion of viscous fluid by the use of analytic functions of a complex variable, which has recently been developed by the reviewer, is ap-

plied to the case of a thin symmetrical Joukowsky airfoil at an arbitrary angle of attack α. The lift and drag coefficients C_L and C_D can be uniquely determined in analytical form without making any special assumption such as Joukowsky's. Numerical values of C_L and C_D are calculated for various angles of attack, for the cases $\epsilon = 0, 0.1, 0.2$, and $R = 0.1, 0.2$, where ϵ is the usual parameter specifying the thickness of the Joukowsky airfoils and R is the Reynolds number. It is found (1) that both C_L and C_D decrease as R increases, (2) that C_L takes a maximum near $\alpha = 45°$, and for a fixed Reynolds number C_L increases as ϵ decreases, and (3) that C_D is nearly independent of α and ϵ.

I. Imai, Japan

2925. **Krzywoblocki, M. Z. v., On the general theory of downwash behind a finite wing in supersonic range,** *Bull. Calcutta math. Soc.* **45,** 1, 21–40, Mar. 1953.

Relying on previous work of Heaslet and Lomax [AMR **1,** Revs. 499, 500; **4,** Rev. 1272] and Spreiter and Sacks [AMR **4,** Rev. 2129], author uses Picard iteration process to calculate approximately downwash behind finite span wings. Work is in tensor notation and examples are included.

M. D. Friedman, USA

2926. **Keune, F., The influence of camber and geometrical twist on low-aspect-ratio wings of finite thickness in subsonic, transonic and supersonic flow,** *Roy. Inst. Technol. Div. Aero., Stockholm, KTH-Aero. TN* 29, 13 pp., 1953.

Influence of camber on low-aspect-ratio wing with arbitrary angle of attack and finite thickness is investigated on the basis of previous work [AMR **7,** Rev. 1546] which included higher-order terms in ratio of wing thickness to span. The forces and moments caused by the camber depend on camber and thickness distribution and are independent from angle of incidence. Pressure distribution varies with angle of incidence, but pressure difference between the upper and lower surface remains unchanged.

From author's summary by G. Guderley, USA

2927. **Warren, C. H. E., A theoretical approach to the design of hydrofoils,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2836, 20 pp., Sept. 1946, published 1953.

Hydrofoils, distinguished by sharp leading edges necessary to avoid spray when cutting the water's surface, are theoretically akin to low-compressibility and low-drag airfoils. The theory of thin profiles, summarized in a most readable form, is used as a tool; first, for a comparative analysis of cavitation speeds and loading limits, the foil of elliptical thickness distribution and logarithmic camberline serving as standard of optimum performance; secondly, for the design of several families of practical airfoils originated by Squire and found only slightly inferior to the above optimum. One family is suitable for struts; another for light loading at highest cavitation speed required for high-speed naval vehicles; a third for high loading required for take-off of hydroplanes. Characteristics beyond the onset of cavitation are not investigated.

J. R. Weske, USA

2928. **Preston, J. H., The calculation of lift taking account of the boundary layer,** *Aero. Res. Counc. Lond. Rep. Mem.* no. 2725, 40 pp., Nov. 1949, published 1953.

A better understanding of the influence of the boundary layer of the aerodynamic characteristics of an airfoil should reduce the need for extensive flight and wind-tunnel testing programs and thus expedite the design of aircraft. There have been attempts in the past to explain the discrepancy between the Kutta-Joukowsky estimated aerodynamic characteristics and the corresponding experimental values. The G. I. Taylor equal vorticity discharge rate theorem is and has been the starting point for the more complete theoretical treatment of the airfoil. Taking into account wake displacement, thickness produced improvements but still left room for further improvement. The author, following the work of Stuper, Nitzberg, and Pinkerton, takes into account the wake camber and, with an improved theoretical basis, establishes good agreement for a pair of 12% symmetrical sections of 6° angle of attack. The paper indicates in brief form how the theory may be extended to include cambered airfoils with plain flaps and the effects of compressibility. Three appendixes are included, exhibiting details of the calculations of some of the required parameter values. This excellent work of Dr. Preston would be enhanced for practical application if his method could be harnessed to our high-speed computing machines.

M. G. Scherberg, USA

2929. **Carpenter, P. J., and Fridovich, B., Effect of a rapid blade-pitch increase on the thrust and induced-velocity response of a full-scale helicopter rotor,** *NACA TN* 3044, 26 pp., Nov. 1953.

A simple theory is given for determining the thrust and induced-velocity response of a rotor to a rapid blade-pitch increase. Nonstationary character of the flow is taken into account by means of apparent mass of air influenced by the rotor disk, while nonuniformity of the downwash is accounted for by simplifying approximations. Forward speed ratio (μ) is assumed as zero. For a stationary hub, two simultaneous differential equations are obtained to determine the thrust and induced velocity as functions of time when the pitch angle and rotor angular speed are given time functions. Test is made of a full-scale model rotor, with rates of pitch increase from 6° to 200° per second. Equations are solved numerically for the particular case tested, and, on the whole, satisfactory agreement with the experimental results is obtained. At high rates of pitch increase, a thrust overshoot of double the normal value, but of short duration, appears obtainable. Results are of practical interest in connection, for example, with a jump take-off.

M. Morduchow, USA

2930. **Travers, S., Resistance of air rarefied by altitude** (in French), *C. R. Acad. Sci. Paris* **237,** 25, 1634–1635, Dec. 1953.

2931. **Williams, M. L., An expression for the gust alleviation factor,** *J. aero. Sci.* **20,** 10, p. 723, Oct. 1953.

2932. **Sherlock, R. H., and Lesher, E. J., Design of chimneys to control downwash of gases,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-80, 14 pp.

Aeroelasticity (Flutter, Divergence, etc.)

(See also Revs. 2923, 2949)

2933. **Payne, P. R., Rotor blade motion in a vertical sharp-edge gust, I, II, & III,** *Aircr. Engng.* **26,** 299, 300, 301; 10–14, 41–45, 80–84, Jan., Feb., Mar. 1954.

These three excellent papers treat by direct methods a systematic investigation of the deflections experienced by constant chord, tapered and twisted, helicopter blades when subjected to sharp-edged gusts. The third paper deals with the problem of forward flight under similar conditions. The case of the rotor axis fixed in space or free to fall is considered.

A nomograph is presented to show deflections experienced as a function of the inertia number and skew angle. The case of

ground rotation at zero net thrust on the blades is shown to produce the most adverse deflection effects.

The admission of forward flight and hovering in the equations has been treated, resulting in a solution which appears to be exact, within the limits of the assumptions. J. B. Duke, USA

2934. **Daughaday, H., and Kline, J., An approach to the determination of higher harmonic rotor blade stresses,** *Cornell aero. Lab. Rep.* CAL-52, 37 pp., Mar. 1953.

Helicopter-blade bending stresses actually measured in flight often indicate the presence of large exciting forces occurring at frequencies from three to ten times the rotor rpm. Special tests conducted at Cornell Aeronautical Laboratory indicated that these stresses, induced by high-frequency excitations, may in some regimes of flight (transition) exceed by as much as 50% the stresses computed on the conventional design criteria where harmonics above the second are neglected. Comparison of test results with blade-bending excitations predicted from a nonuniform downwash distribution, based on Mangler's theory, seems to indicate that this nonuniformity of the downwash is probably the primary source of these high-order excitations. Methods for applying the results to rotor-blade design are briefly described.

W. Z. Stepniewski, USA

2935. **Birnbaum, W., The plane problem of the flapping wing,** *NACA TM* 1364, 38 pp., Jan. 1954. (Translation from *ZAMM* **4**, 4, 277–292, 1924.)

Unsteady vortex theory is used to obtain expressions for the aerodynamic forces on two-dimensional wing sections in incompressible flow. The case of steady harmonic oscillations in bending and torsion is solved in general. The specific problems of propulsion by wing flapping and the simple bending-torsion flutter problem are discussed. The latter is compared with some wind-tunnel experiments. H. P. Liepman, USA

2936. **Merbt, H., and Landahl, M., The oscillating wing of low aspect ratio—results and tables of auxiliary functions,** *Roy. Inst. Technol., Div. Aero. Stockholm, TN* 31, 32 pp., 1954.

The theory of AMR **6**, Rev. 3175 is applied to a slender delta wing oscillating in vertical translation, pitch, roll, torsion, and bending. The pressure distribution and force and moment coefficients have been determined in terms of Mathieu functions. A number of special functions have been evaluated and are given in tables and graphs, enabling the pressure, forces, and moments to be obtained very easily. All results are subject to the limitations of the linearized theory as stated in the afore-mentioned review. A. W. Babister, Scotland

2937. **Yeh, G. C. K., and Martinek, J., Effects of wing twist on the response of an airplane encountering a sharp-edged gust,** *J. aero. Sci.* **20**, 12, 827–834, 860, Dec. 1953.

The acceleration response to a sharp-edged gust of an airplane with one degree of freedom, vertical motion, is calculated using unsteady-lift functions for incompressible flow, assuming that wing flexibility can be taken into account by considering an average twist which is proportional to the normal acceleration. This assumption is reasonable if the lift contributed by the tail and fuselage is not large, the mass of the wing (including nacelles, tip tanks, etc.) is small, and the effective spring constant is selected properly. Also, the neglect of the pitching moment while including twist can be justified if the wing is relatively flexible, the moment of inertia of the airplane is large, and the airplane has little or no sweep. However, if the wing is highly sweptback, the practical significance of results obtained by assuming that a sharp-edged gust hits all points on the leading edge simultaneously is in doubt.

Within the approximation made, wing elasticity is shown to result in considerable alleviation effect (for the negative spring constants, representative of sweptback wings, considered by the authors), but to have little effect on the time at which maximum acceleration is attained. Authors' discussion of the relative effects of mass parameter and flexibility parameter is obscured by the fact that their flexibility parameter contains the mass parameter. If the parameters are separated, the calculated results for the alleviation factor can be shown to be substantially independent of mass parameter and to be obtainable approximately from a rigid-wing analysis (*NACA TN* 2036, e.g.), using a lift-curve slope corrected for static aeroelastic effects (*see NACA TN* 2608, e.g.) instead of the ordinary lift-curve slope.

F. W. Diederich, USA

2938. **Beatrix, C., Exchange of energy between modes in flutter** (in French), *Rech. aéro.* no. 35, 53–54, Sept.-Oct. 1953.

2939. **Beatrix, C., Note on calculation of flutter in compressible subsonic flow** (in French), *Rech. aéro.* no. 35, 54–55, Sept.-Oct. 1953.

2940. **Larrabee, E., A method for stabilizing the longer period oscillation of a model flying in a closed wind tunnel with freedoms in pitch and heave,** *J. aero. Sci.* **20**, 10, p. 728, Oct. 1953.

A simple scheme is described in which a small auxiliary airfoil is used to damp out unstable heaving motions of an airplane model in a wind tunnel when the model has freedom of pitch and heave. The long-period mode caused by tunnel-wall interference is the unstable mode and the one most affected by the damper. The damper is said to have no significant undesirable effects.

G. B. Schubauer, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 2746, 2752, 2774, 2908, 2917, 2929, 2933, 2934, 2958)

2941. **Boyum, W. B., Ferguson, R. W., and Partlow, J. G., Methods of starting gas turbine generator sets,** *Combustion* **25**, 9, 43–47, Mar. 1954.

Paper describes a number of special problems involved in starting gas turbines. Representative starting equipment is described and electrical considerations are explained.

From authors' summary

2942. **Wittenberg, H., Cruise control procedures for turbine-engined aircraft** (in Dutch), *Ingenieur* **65**, 36, L.27–L.32, Sept. 1953.

The variation of the air miles per pound fuel consumption with altitude and speed for aircraft with gas turbines is discussed. For purposes of comparison with piston-engined aircraft, the properties of aircraft with propeller gas turbines are especially considered.

The several methods of cruise control are explained with the aid of a cruising grid. The climbing flight at constant true air speed and constant turbine rpm appears to be the best method of cruising. In an example, the gain in fuel consumption and payload for this cruising method as compared with flight at constant altitude or at constant indicated air speed is illustrated.

The effects of the discussed properties on the operational use of turbine-engined aircraft are briefly considered.

From author's summary

2943. Pollock, W. A., Testing large steam turbines with weighing tanks, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-66, 7 pp.

2944. Ireland, M. L., Jr., Ritchings, F. A., and Crocker, S., Comparison of land and marine steam-power-plant practice, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-99, 39 pp.

2945. Gale, A. G., and Chase, H. J., Some notes on development of turbine-generator sets for shipboard service, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-89, 7 pp.

2946. Alford, J. S., Dimensional stability and structural integrity of casings for aircraft gas turbines, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-231, 31 pp.

Compressor casings made of five different cast light alloys were examined for diametral distortions after one, two, and three 150-hr endurance tests on turbojet engines. The consequences of blade failure as regards structural integrity of casings is reviewed in light of operating experiences. Analysis and formulas are presented for casing stresses and deflections due to inertia loads and also nonuniform radial loads.

From author's summary by C. H. Wu, USA

2947. Casci, C., On the compound engine (in Italian), *Aerotecnica* **33,** 4, 263–269, Aug. 1953.

Considering that the utilization of exhaust gases from a turbine may provide useful work from the turbine shaft to motor shaft, as well as drive the turbocharger, it is noted that a limit to its working capacity is determined by temperature of inlet gases of the turbine. It is possible to obtain a higher temperature of turbine inlet gases by properly mixing the exhaust gases with the air from the compressor. Several diagrams show the advantage of this procedure.

Calculations and diagrams are presented for an engine operating with Otto or diesel cycle. Special notice is taken, together with performance and technological remarks, of the advantage of the diesel cycle over the Otto cycle.

From author's summary

2948. Birmann, R., The elastic-fluid centripetal turbine for high specific outputs, *Trans. ASME* **76,** 2, 173–185, Feb. 1954.

Paper describes the radial inward-flow (or centripetal) turbine for elastic fluids. The author first discusses the theoretical aspects of the turbine design and then compares the physical size of various axial-flow and centripetal turbine wheels designed for the same power output. Then he describes various specific applications where he claims that the high-specific-speed centripetal turbine was better suited than the axial-flow design. These include a test turbine, mechanical drive for a centrifugal steam pump, marine propulsion power plant for a submarine chaser, exhaust turbine drives for engine superchargers, and small jet-propulsion engines. G. R. Fusner, USA

2949. Huppert, M. C., and Benser, W. A., Some stall and surge phenomena in axial-flow compressors, *J. aero. Sci.* **20,** 12, 835–845, Dec. 1953.

The desire for increased performance of jet engines has led to high pressure-ratio axial-flow devices; for these, stalling or surging of the compressor can lead to severe problems when acceleration or off-design performance is desired.

Authors find that, at speeds around design value, stall of multistage compressors is due to performance deterioration of later stages; low-speed stall is associated with inlet stages; intermediate-speed stall may be due to simultaneous deterioration of several stages; and that these problems become increasingly acute as small pressure ratios increase.

Single-stage compressors have two distinct types of stall patterns: progressive stall, originating at blade ends and extending over a limited portion of blade, and root-to-tip stall, involving entire blade. Some analysis and experimental results of these are given.

Results of hot-wire studies give some insight on characteristics of multistage stall. A thorough discussion of the sources and nature of stall is given.

Compressor surge is treated on the basis of linearized system performance characteristics. Authors point out that surge can also be associated with cyclic stalling and unstalling of compressors following an initial stall; this is induced by the discontinuous pressure-ratio flow characteristics of the stalled blade. Authors present treatment of this type of surge. It is pointed out that, in actual operation of engines, the small receiver volume can result in stall without becoming a cyclic surge.

Paper presents a generalized treatment of stall and surge problems, and classifies these. Applications to specific engines must include effects ignored in this paper for the sake of generality.

B. W. Augenstein, USA

2950. Fowler, H. S., and Walker, V., Fluid flow in turbomachinery, *Trans. Instn. Engrs. Shipb. Scot.* **97,** 3, 113–152, 1953–1954.

The value to the turbomachinery designer of air-flow tests on models of the various components is discussed, and the facilities for carrying out such tests at Pametrada are described. Model testing is illustrated with descriptions of flow investigations in the ducting of the Pametrada gas turbine. The uses and limitations of cascade testing of turbine and compressor blades are discussed and the importance of the new high-speed variable-density wind tunnel is explained. The main features of the air turbine and its instrumentation are described.

From authors' summary

2951. English, R. E., and Cavicchi, R. H., One-dimensional analysis of choked-flow turbines, *NACA Rep.* 1127, 18 pp., 1953.

Supersedes article reviewed in AMR **6,** Rev. 2009.

2952. Medici, M., Research on pump's performance by different reductions of the impeller diameter (in Italian), *Ric. sci.* **24,** 1, 76–85, Jan. 1954.

Paper deals with the results obtained in research work, sponsored by the CNR and carried out at the Laboratory for Water Engines in the Machine-Institute at the University of Padua, on pumps with a Francis impeller, or with a half-axial blade runner, in order to establish the performance of the pump for different reductions of the impeller diameter.

From author's summary

2953. Burrell, G., and Butler, F. G., A study in applied physics: locating the piston pin to minimize piston slap, *GM Engng. J.* **1,** 3, 38–43, Nov.-Dec. 1953.

The change in direction of a piston during combustion is accomplished by a reversal of certain forces on the piston. One of the possible results is an audible piston slap. By properly locating the piston pin, the behavior of the piston may be controlled so that the slap tendency is minimized. An analytical method developed and used satisfactorily demonstrates how the sound application of basic physics enables the pin location to be predetermined and the slap tendency reduced. This method was first used in 1948 in connection with the development of the Oldsmobile rocket engine.

From authors' summary

2954. **Persh, J., and Bailey, B. M., Effect of various arrangements of triangular ledges on the performance of a 23° conical diffuser at subsonic Mach numbers,** *NACA TN* 3123, 36 pp., Jan. 1954.

Space limitations frequently make use of the most efficient length and angle of duct diffuser impracticable. With shorter length and greater angles, flow may be unstable. Tests here reported show such instability can be prevented by adding series of "ledges," or protuberance transverse to direction of flow, having height about one tenth of inlet boundary-layer thickness. In particular, roughness strip near inlet is very effective. Effect on both static and total pressure is extremely small.

C. W. Smith, USA

2955. **Backer, G. H., Design and performance of an adjustable two-dimensional nozzle with boundary-layer correction,** *J. aero. Sci.* **21,** 1, 50–56, Jan. 1954.

The use of Laval nozzles of the axially symmetric and two-dimensional type in low working-section pressure, supersonic wind tunnels is discussed. As a method of overcoming the limitations of the former in regard to precision of manufacture and geometrical fixation, author proposes a two-dimensional-type nozzle. The design of such a nozzle, including boundary-layer displacement corrections (based on high-density methods) for a nominal Mach number of 3.106, is presented along with test results from traverses in a low-density, free-jet, wind tunnel (static jet pressure = 85 microns of Hg). The experimental results presented show the effects of varying the mass flow and exit-to-throat area ratio; in the first instance it is shown that, as the mass flow decreases, the viscous region increases until it entirely fills the exit and, in the latter case, it is shown that, as may be expected, the boundary layer tends to fill more of the exit as this ratio is increased, while the Mach number varies in the usual manner. Experimental curves showing the variation in pressure and Mach number across the tunnel cross section are included. Author concludes that, within limits, the concept of a two-dimensional, adjustable area-ratio nozzle is feasible, and, from the results of axial traverses, that such type nozzles would be satisfactory for the testing of slender bodies of revolution.

This paper should prove valuable to all interested in wind-tunnel research; reviewer would like to see included in this work some discussion of the validity of linearized continuum results in the low-pressure regime, and especially in relation to the boundary-layer displacement problem. G. V. Bull, Canada

2956. **Robinson, W. P., and Yost, J. H., Design and development problems in large helicopter power transmission systems,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-224, 20 pp.

2957. **Burk, S. M., Jr., and Healy, F. M., Comparison of model and full-scale spin recoveries obtained by use of rockets,** *NACA TN* 3068, 63 pp., Feb. 1954.

Report discusses the use of spin-recovery rockets as a safety device for experimental aircraft. Good agreement was obtained between model and full-scale airplane. H. R. Ivey, USA

Flow and Flight Test Techniques

(See also Revs. 2815, 2838, 2908, 2911, 2940, 2955, 3042, 3072)

2958. **Faulders, C. R., An interferometric study of the boundary layer on a turbine nozzle blade,** *Trans. ASME* **76,** 1, 61–66, Jan. 1954.

In order to arrive at a better understanding of the means for reducing losses in cascades of turbine blades, interferometer pictures of a two-dimensional cascade were evaluated. Main objectives were location of boundary-layer transition points and critical Reynolds number. Mach number range and throat Reynolds number range were 0.3 to 0.75 and 80,000 to 250,000, respectively.

Results indicate that the Mach number has negligible effect on transition. However, the thickness critical Reynolds number turned out to be a strong function of throat Reynolds number and not only a function of turbulence level, as frequently assumed. A laminar velocity profile determined from the density distribution after Crocco showed that the boundary-layer history has no measurable effect on the profile.

Paper shows merits of interferometer tests for boundary-layer studies. H. J. Ramm, USA

2959. **Sellerio, A., On the use of dry ice for the visualization of air streams** (in Italian), *Aerotecnica* **33,** 6, 398–400, Dec. 1953.

The method employed is described and some results of its application are shown. From author's summary

2960. **Hansen, M., Scholz, H., and Stebel, O. J., Model experiments on investigation of flow in soaking pit furnaces** (in German), *Arch. Eisenhüttenw.* **24,** 9/10, 375–381, Sept./Oct. 1953.

2961. **Head, V. P., Coefficients of float-type variable-area flowmeters,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-208, 24 pp.

The calibration of "rotameters," devices for measuring flow rates by use of floats rising in tapered columns under the influence of upward flow, was studied. Measured meter coefficients were related to fluid viscosity, density, and compressibility, if a gas, and to shape of float and tube. The problem was to develop functional relations between a meter coefficient and variables listed, so that different types of instruments might be compared and calibrations determined without extensive laboratory measurements.

Measured coefficients were related to a viscosity parameter, similar to the Reynolds number for flow around the float, and an area parameter, selected as the ratio of tube diameter D_T at the point to which the float rose for a given flow and float diameter D_F. Comparisons were made with theoretical analyses. Seventy-three tests selected from production files were used. Author reports development of correlation techniques whereby extensive individual calibrations might be eliminated.

Reviewer examined relation between discharge and viscosity and found no correlation in range of Reynolds numbers reported (600–85,000). If analysis is made on the basis of variable-orifice flow and a coefficient of discharge C_d determined, using instrument head reading as distance above apex of cone formed by tapered tube, that coefficient is closely a constant for a particular float and tube geometry and float and liquid density for all ranges of flow. Use of this relation would simplify author's work and afford a better basis for calibration and comparison.

M. C. Boyer, USA

2962. **Montens, Flow rate measurements with radioactive isotopes** (in German), *Wasserwirtschaft* **44,** 3, 63–65, Dec. 1953.

2963. **Jorissen, A. L., On the evaluation of the accuracy of the coefficient of discharge in the basic flow-measurement equation,** *Trans. ASME* **75,** 7, 1323–1325, Oct. 1953.

See AMR 6, Rev. 2615.

2964. Iwanami, S., On the study of the technical viscometer (3rd report), *Mem. Fac. Technol., Tokyo Metrop. Univ.* no. 3, 29–34, 1953.

Author investigates the hydraulic characteristics of short tubes having different exit configurations. His motivation was to determine tube designs, each suitable for measuring a particular range of kinematic viscosity. Results show that the greater the kinematic viscosity, the greater the angle of taper of the end of the tube should be in order to maintain a linear relation between the kinematic viscosity and the time of discharge of a known quantity of the liquid. M. S. Macovsky, USA

2965. Iwanami, S., On the study of the technical viscosimeter (4th report) (in Japanese), *Trans. Soc. mech. Engrs. Japan* **19,** 85, 101–107, Sept. 1953.

Slow motion of a viscous fluid flowing out from a semi-infinite space ($x > 0$) into a circular pipe ($x < 0$) is considered by the use of the Stokes approximation in the form of Korteweg's principle of minimum energy dissipation. It is assumed that the Poiseuille flow sets up just at the entry ($x = 0$), while the stream function in the half space ($x > 0$) is assumed such that

$$\psi = cr_0^2 \sin^2\theta \quad (r > r_0);$$

$$\psi = (r/r_0)^2\{A' - B'(r/r_0) - C'(r/r_0)^2\} \sin^2\theta \quad (r < r_0)$$

r_0 being the radius of the pipe. The mouth correction of pipe due to additional loss of energy at the entry is estimated as

$$\Delta l < 0.44d \quad (d = 2r_0)$$

This compares favorably with the author's previous experimental result $\Delta l = 0.385d$. I. Imai, Japan

2966. de Leiris, H., Pneumatic extensometry (in French and English), *Laboratories* no. 7, 7–12, Sept. 1953.

2967. Anonymous, Vibrating string extensometers (in French and English), *Laboratories* no. 7, 45–46, Sept. 1953.

2968. Grégoire, M., Electronic method for measuring unsteady aerodynamic forces (in French), *Rech. aéro.* no. 35, 31–34, Sept.-Oct. 1953.

2969. Pittoni, M., Wind-tunnel tests on a horizontal tail model with fixed and free elevator (in Italian), *Aerotecnica* **33,** 6, 410–413, Dec. 1953.

The lift and hinge-moment coefficients at fixed stabilizer and elevator angles have been determined. Moreover, the free elevator angles for different stabilizer and tab angles have been observed, and the corresponding lift coefficients determined. The elevator was statically balanced. From author's summary

2970. Peacock, D. W., British Railways wind tunnel, *Nature* **172,** 4391, 1165–1166, Dec. 1953.

Thermodynamics

(See also Revs. 2879, 2992, 3005, 3006, 3007, 3031, 3072)

2971. Popoff, K., On the thermodynamics of irreversible processes (in French), *ZAMP* **5,** 1, 67–86, Jan. 1954.

The state of a system is determined by n variables $X_i = \xi_i - \xi_i^0$, $i = 1, 2, \ldots n$, where the ξ_i^0 correspond to equilibrium conditions. The entropy difference, correct through second-order terms, between the actual state and the equilibrium state is

$$\Delta S = -1/2_i\Sigma_k g_{ik} X_i X_k,\ g_{ik} = g_{ki},\ i = 1, 2, \ldots n$$

The "fluxes" X_i' (time derivatives of X_i) are related to "forces" X_k (partial derivatives of $-\Delta S$ with respect to X_k) through the phenomenological relations $X_i' = \Sigma_k L_{ik} X_k$.

Author assumes the conditions $X_i(+\infty) = 0$ and notes that these impose n conditions on the L_{ik} in addition to the n initial conditions specified through $\xi_1^0, \ldots \xi_n^0$. The $2n$ conditions are satisfied by the n second-order differential equations

$$d^2X_i/dt^2 = X_i' = -\partial(\Delta S)/\partial X_i$$

In the general case, the L_{ik} depend only on the g_{ik}. The theory is applied to problems on heat conduction and mass transfer between different phases. S. S. Penner, USA

2972. Popoff, K., The thermodynamics of irreversible processes and the phase theory (in French), *C. R. Acad. Sci. Paris* 238, 331–333, Jan. 1954.

The general phenomenological relations of irreversible thermodynamics, as developed by the author for systems at constant pressure and temperature, have been applied to two-phase systems in which one phase is a pure substance. An explicit relation is obtained for the transfer of mass as equilibrium is approached; it is found that mass transfer between the two phases decreases exponentially with time. S. S. Penner, USA

2973. Epstein, L. F., Hibbert, Celesta J., Powers, M. D., and Roe, G. M., The third virial coefficient of a Lennard-Jones gas by Kihara's method with tables for the 6–9 potential, *J. chem. Phys.* **22,** 3, 464–468, Mar. 1954.

Authors calculate the third virial coefficient and its first and second derivatives as a function of the generalized temperature for the Lennard-Jones potential function, with the repulsive force varying as the inverse ninth power instead of twelfth. The procedure followed in evaluating the triple integral for $C(T)$ is essentially that suggested by T. Kihara [*J. phys. Soc. Japan* **3,** 265, 1948; and **6,** 184, 1950; see also *Revs. mod. Phys.* **25,** 831, 1953], consisting of a power-series expansion in the generalized temperature θ with the coefficients given by double integrals. Authors use a somewhat different form of the double integral to facilitate numerical calculations and to increase the accuracy and recalculate Kihara's values, also extending their range. They point out an error in Kihara's equation (inclusion of an extra factor of 3/2). Graphical comparisons are given for the normalized third virial coefficient and its first and second derivatives as a function of the generalized temperature θ for the case of the 9-6 and 12-6 Lennard-Jones potentials, indicating appreciable divergencies at the low temperatures, or high θ. The results are tabulated for a range of θ from zero to 2.00. G. A. Hawkins, USA

2974. Masi, J. F., Survey of experimental determinations of heat capacity of ten technically important gases (Air, NH_3, CO_2, CO, H_2, CH_4, NO, N_2, O_2, H_2O), ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-206, 22 pp.

All of the literature reports of determinations of heat capacity of gases in the period 1925–1952, inclusive, have been reviewed, and those pertaining to any of the ten gases—air, NH_3, CO_2, CO, H_2, CH_4, NO, N_2, O_2, and H_2O—are tabulated. The four direct and six indirect methods used in these measurements are briefly described. By means of graphs, the reported results for several of the gases are compared with values calculated from molecular data and an equation of state. There is included a table of the most recent values of heat capacity at one atmosphere for the ten gases. From author's summary

2975. **Dapoigny, J., Kieffer, J., and Vodar, B., Some results of water compression in a shock wave** (in French), *C. R. Acad. Sci. Paris* **238,** 2, 215–217, Jan. 1954.

By means of x-ray absorption techniques, authors measured the density field and wave-front velocity in a column of water when an explosive charge is set off at one end. The pressures computed from these measurements were of order 5×10^5 psi. Comparison of the resulting $p(v)$ diagram with Bridgman's static measurements indicates that no freezing has occurred; the attempt to estimate instantaneous temperatures is open to question, however, in view of the uncertainty as to the correct thermodynamic equation of state. L. Trilling, USA

2976. **Böttger, A study of the compressibility of liquids,** *Engng. Rev., Prague* no. 10, 28–35, Oct. 1951.

There are two types of liquids known to the technical physicist: the practically compressible liquids, and the incompressible ones. All internal-combustion-engine fuels (hydrocarbons) belong to the first group. The modulus of elasticity E is employed as the measure of the liquid compressibility.

The dependence of the compressibility of the diesel engine fuels upon the pressure was established a long time ago (Sass, Alexander, Pischinger, Blaum); however, E has always been given as a constant in order to enable the mathematical solution of the wave equations. In the region of pressures higher than 100 atm, E asymptotically approaches a constant limit value, but if pressures become lower than 50 atm, the dependence of E upon the pressure becomes much more pronounced. The results of Alexander and those of Blaum are different. Alexander's curve has given the author an idea that a remnant of unliquified vapor phase exists in every liquid, once the liquid has been subjected to a negative pressure.

Author establishes a formula giving E_s of the liquid-vapor mixture, assuming that Hooke's law applies first to the mixture, then to the liquid alone, and admitting that Laplace's law may be applied to the compressed vapors. Alexander's curve matches almost perfectly the curves calculated by the author, but this theory does not fully clarify the results of measurements obtained by Blaum.

Author then discusses in greater detail the effect of quantity E upon the velocity of pressure-wave propagation in the liquid-vapor mixture. (Blaum published the results of his direct measurements of the velocities of pressure propagation in the delivery manifolds of various inside diameters: curves of variation of E versus p were deduced from these measured values of the velocities of pressure propagation.) Author comes to the conclusion that the only remaining method suitable for additional experiments is the method of direct measurements of the velocity of pressure propagation by means of electrical and hydraulic devices (pumps, hydraulic valves, oscillographs). Such measurements could furnish a rather accurate impression about the variations of quantity a and, simultaneously, of E/γ in relation to pressure. [$a = (kE)^{1/2}$, where k is the ratio of the acceleration of gravity to the liquid specific weight γ at pressure p_x.]

L. J. Tison, Belgium

2977. **Michels, A., Wassenaar, T., Louwerse, P., Lunbeck, R. J., and Wolkers, G. J., Thermodynamical functions of propene at temperatures between 25° C and 150° C and at pressures up to 2500 atm,** *Appl. sci. Res.* (*A*) **4,** 1, 34–38, 1953.

2978. **Michels, A., Wassenaar, T., and Van Seventer, W., Isotherms of air between 0° C and 75° C and at pressures up to 2200 atm,** *Appl. sci. Res.* (*A*) **4,** 1, 52–56, 1953.

2979. **Bell, S., and Schaaf, S. A., Aerodynamic forces on a cylinder for the free molecule flow of a nonuniform gas,** *J. Amer. Rocket Soc.* **23,** 5, 314–317, 322, Sept.-Oct. 1953.

Aerodynamic forces on a cylinder in a rarefied gas stream, which is not in Maxwellian equilibrium, have been calculated for the case where the molecular-mean-free path is large compared to the cylinder diameter. The analysis shows that a lift force is exerted on the cylinder due to the presence of velocity or temperature gradients in the gas stream. Also, the drag force on the cylinder is increased above that experienced in a gas stream at Maxwellian equilibrium. The analysis is restricted to the case of small (with respect to a molecular-mean-free path) temperature and velocity gradients. G. Goodwin, USA

2980. **Strehlow, R. A., The temperature dependence of the mutual diffusion coefficient for four gaseous systems,** *J. chem. Phys.* **21,** 12, 2101–2106, Dec. 1953.

See AMR **6,** Rev. 3915.

2981. **Robitzsch, M., Adiabats of water drops** (in German), *Z. Meteor.* **7,** 6, 172–175, June 1953.

A very simple and helpful method for drawing a wet adiabat on the meteorological thermodynamic diagram (e.g., the pseudo-adiabatic diagram on which $(-p^{R/c_p})$ is plotted vs. T, and which contains lines of constant equivalent temperature) is described. One advantage of the method is that it readily permits extension to special conditions one may wish to consider.

The wet adiabat itself takes no account of the effect of surface tension when the condensed water is present in small droplets. This effect, which depends critically on the drop radii, is described by means of modified wet adiabats called by the author "drop adiabats." These curves indicate a substantially less rapid decrease in temperature with decrease in pressure than the wet adiabat; the latter, of course, corresponds to drops of infinite radius of curvature.

The numerical values of the effect of surface tension on vapor pressure are taken by the author from his earlier paper [AMR **5,** Rev. 559]. In reviewer's opinion, these values are bigger than they ought to be, and hence the effect illustrated here is rather less important in meteorology than the paper indicates.

W. Hitschfeld, Canada

2982. **Peter, S., Viscosity and self-diffusion of liquids** (in German), *Z. Naturforsch.* **9a,** 2, 98–104, Feb. 1954.

A simple model of liquids is presented and relationships are developed between the viscosity and the velocity of sound, density, and the activation energy of changes in position. Agreement is obtained between calculated and experimental viscosity coefficients for nonassociated simple organic liquids and monatomic metals. Values of self-diffusion coefficients are also obtained. Systems with structural viscosity are considered.

W. L. Sibbitt, USA

2983. **Markgraf, H.-G., and Nikuradse, A., Volume effect in binary mixture of some organic liquids** (in German), *Z. Naturforsch.* **9a,** 1, 27–34, Jan. 1954.

2984. **Jordan, G. V., Jr., Separation of immiscible liquids by means of porous membranes,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-221, 14 pp.

In the process industry, porous media are generally associated with filtration and diffusion. However, porous membranes also can be utilized for the separation of immiscible fluids—liquids from gases, gases from liquids, liquids from liquids.

The phenomenon of interfacial tension separation as applied to liquid-liquid separatory systems is explained, together with a description of the porous membranes employed. Basic design data and operational features of liquid separatory units and systems are presented. Interesting applications and installations in the process industries are included.

From author's summary

2985. **Verschaffelt, J. E., Equilibrium of mixed fluids** (in French), *Acad. roy. Belgique, Bull. Cl. Sci.* (5) **39,** 7, 612–621, July 1953.

The velocity $\mathbf{u}$ of a mixed fluid is $\mathbf{u} = \Sigma x_n \mathbf{u}_n$, where $\mathbf{u}_n$ is the velocity of the constituent n of relative mass x_n, $\Sigma x_n = 1$. The condition for diffusion equilibrium $\mathbf{u} = 0$ depends, then, on the unit of mass, e.g., mole or gram. The consequences of this effect are discussed in detail and compared with the conclusions of other authors.

L. Meyer, USA

2986. **Verschaffelt, J. E., Addition to the equilibrium of a mixed fluid** (in French), *Acad. roy. Belgique, Bull. Cl. Sci.* (5) **39,** 2, 169–174, Feb. 1953.

Introducing the possibility of chemical reactions between the species participating in a diffusion equilibrium as discussed in another paper (see preceding review) leads to the conclusion that diffusion and chemical equilibrium are simultaneously possible only in the absence of temperature and pressure gradients.

L. Meyer, USA

2987. **Mortlock, A. J., The effect of tension on the thermoelectric properties of metals,** *Austral. J. Phys.* **6,** 4, 410–419, Dec. 1953.

Author measured effect of elastic strain on thermoelectric power of copper, gold, silver, platinum, palladium, nickel, aluminum, titanium, molybdenum, iron, and tungsten. One leg of a single-wire thermocouple circuit was stressed, in various increments, while the junction temperature differences were varied from 40 to 400 C. The results obtained for gold are not in agreement with results reported by G. S. Meyer [*Wied. Ann.* **59,** 134, 1896].

D. Bendersky, USA

2988. **Zadumkin, S. N., Surface tension and heat of evaporation of metals** (in Russian), *Doklādi Akad. Nauk SSSR (N.S.)* **92,** 1, 115–118, Sept. 1953.

Author lists available theoretical and experimental methods for finding values of surface tension for solid and molten metals. Theoretical methods depend on knowledge of the numbers of free electrons, and these are not known accurately.

Alternatively, it is possible to find a relation between surface tension and some other known physical property of the metal. Author derives a semiemprical formula, relating surface tension of solid metals to their latent heats of sublimation and to their basic crystal lattice structures. He shows that his formula usually agrees well with established empirical data.

Y. R. Mayhew, England

2989. **Sodha, M. S., and Varshni, Y. P., Latent heat of sublimation of fifteen salts from spectroscopic and thermochemical data,** *Indian J. Phys.* **27,** 10, 520–522, Oct. 1953.

2990. **Decker, G. E., and Stiehler, R. D., Temperature measurements in the Mooney viscometer,** *ASTM Bull.* no. 195, 45–51, Jan. 1954.

Authors find that the thermal conductivity of the insulating materials (such as hard rubber) used for supporting the thermocouple in the die cavity of the Mooney viscometer is small, but still too large for reliable measurement of the rubber temperature. Also, these materials may be too fragile for this purpose.

Authors' study also includes results on temperature differentials, of the dies and die cavity, existing in the presence of absence of rubber. Results indicate that the "integral unit" transfers heat more rapidly but reflects more of the gradients in the platens than the "regular unit" does.

From authors' summary

2991. **Sims, L. G. A., Measuring fine temperature changes,** *Engineering* **177,** 4588, 15–16, Jan. 1954.

Present investigations with which the author is concerned conveniently employ thermocouples and, since the properties under investigation vary appreciably with temperature, it is desirable to measure them using small temperature differences, and it is preferred to aim first at the smallest feasible values. It is felt that study of the matter upon the above lines leads to the conclusion that accuracy might be achieved on 0.01° C measurements to approximately 1%, but this demands a thermal datum constant for several minutes to approximately 0.0001° C, and represents about the limit of performance of a base-metal couple or a cold junction. On the other hand, it may be fairly stated that this degree of sensitivity contributes to high accuracy in calorimetry.

From author's summary

Heat and Mass Transfer

(See also Revs. 2734, 2772, 2916, 2988, 3022, 3023, 3024, 3072)

2992. **Blackwell, J. H., A transient-flow method for determination of thermal constants of insulating materials in bulk. Part I. Theory,** *J. appl. Phys.* **25,** 2, 137–144, Feb. 1954.

This is a theoretical paper, largely mathematical, dealing with the computation of thermal conductivity from the time-temperature observations obtained from a thermal conductivity probe. A criticism of existing techniques of computation is given and a new equation is proposed, based on "short time" and "long time" combined solutions. This technique is intended to eliminate errors not accounted for in previous solutions, notably contact error.

The paper should be of interest to those who have followed the development of the thermal conductivity probe.

F. C. Hooper, Canada

2993. **Coles, W. D., Experimental determination of thermal conductivity of low-density ice,** *NACA TN* 3143, 12 pp., Mar. 1954.

The thermal conductivity of low-density ice has been computed from data obtained in an experimental investigation of the heat transfer and mass transfer by sublimation for an iced surface on a flat plate in a high-velocity tangential air stream.

The results are compared with data from several sources on the thermal conductivity of packed snow and solid glaze ice. The results show good agreement with the equations for the thermal conductivity of packed snow as a function of snow density. The agreement of the curves for packed snow near the solid ice regime with the values of thermal conductivity of ice indicates that the curves are applicable over the entire ice-density range.

From author's summary

2994. **Mischke, C. R., and Farber, E. A., An accurate method for the determination of the thermal conductivity of insulating solids,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53–A-185, 7 pp.

Authors describe a guarded hot-plate apparatus that does not

differ materially from many existing hot plates. There is some degree of novelty in their method of mounting thermocouples and in their cold-plate cooling system. They fail to establish any clear advantage for their methods over carefully designed and constructed standard hot-plate apparatuses. Their cold-plate cooling system must be difficult to control.

They report a few test results, most remarkably a substantial variation with age in plate glass.

F. C. Hooper, Canada

2995. **Kolesnikov, A. G., Variations of water temperature in reservoirs in wintertime** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **92,** 1, 37–40, Sept. 1953.

The question of variation of water temperature in a reservoir in wintertime is solved. In this season the temperature is influenced on the top side by the ice-covering, formed on the surface of the water; on the under side by the ground, in which a certain quantity of warmth is accumulated.

Author supposes that the temperature of the water and of the ground depends on the time and on the vertical coordinate z only, $t = t(z, \tau)$. He forms differential equations for the variation of the temperature in the water ($-l < z < 0$) and in the ground ($0 < z < H$, where H is sufficiently large depth, practically the depth of zero temperature amplitudes). The solution is obtained in the form of infinite series. The obtained solution is discussed.

K. Rektorys, Czechoslovakia

2996. **Aitchison, G. D., Simplified measurements of soil temperature and soil moisture,** *Austral. J. appl. Sci.* **4,** 3, 418–426, Sept. 1953.

Paper describes the development of apparatus for measuring soil temperature and moisture in place. For temperature measurement, a thermistor type of semiconductor contained in a plastic mounting and embedded in the soil is used. Resistance measurements are made with a d-c bridge. Accuracy is described as being ±0.2 C for short-term (diurnal) changes of soil temperature, and ±1.0 C for long-term (annual) cycles. This latter is with calibrations at beginning and conclusion of the measuring period. The range of the instrument described is 0 to 50 C, although there appears no reason why this range could not be extended.

For moisture measurement, the paper describes development of a bridge for use with the gypsum-block type of soil-moisture meter developed by Bouyoucos and Mick. The accuracy of the moisture determination is not included, but it is indicated that the instrumental accuracy of the bridge is "more than commensurate with other aspects of the method."

P. P. Brown, USA

2997. **Wardlaw, R. L., An approximate method for estimating the transient heat flow distribution in a de-icing pad,** *Nat. aero. Establ. Canad.* LR-95, 8 pp., 5 figs., Jan. 1954.

De-icing systems of the cyclic electro-thermal type make use of heater pads consisting of a heater element protected on each side by an insulating layer. In order to establish the desirable characteristics of such pads, the present study has been made of an idealized model with a step input of power, under simple boundary conditions.

It is shown, for a neoprene insulated heater pad with a 0.015-inch outer cover, that no energy saving is realized by increasing the inner insulation beyond 0.040 inch.

From author's summary by M. Tribus, USA

2998. **Martin, B. W., and Cohen, H., Heat transfer by free convection in an open thermosyphon tube,** *Brit. J. appl. Phys.* **5,** 3, 91–95, Mar. 1954.

Paper presents experimental data for heat transfer by free convection in a heated vertical tube closed at the lower end. Glycerine, air, and water were used as the working fluids. A 2-in. ID brass tube with an over-all length of 47.5 in. was used as the heat-transfer surface. Five equal sections along the tube were heated electrically in an effort to maintain uniform surface temperature. Thermocouples were embedded in the inner wall to determine surface temperature. The tube was covered with a 6-in. diam copper casing $^1/_4$ in. thick, and the annulus between the tube and the outer case was filled with granulated cork. Thermocouples were mounted in the outer case for determining the temperature difference between the tube and the case, thus estimating the external heat losses. The estimate of these losses is based on a special test previously run but not described.

Tests were conducted over the following Grashof number range: Glycerine $G_r \times 10^{-3}$ from 0.000145 to 68.3; air $G_r \times 10^{-4}$ from 0.834 to 5.74; water $G_r \times 10^{-1}$ from 0.0502 to 196. There was some oscillation of flow during the glycerine test, but the results agree quite closely with the theoretical.

Author leaves some doubt as to the accuracy of the external heat losses, and he suggests that some better technique is needed for determining just what type of flow exists—laminar or turbulent.

C. C. Eckles, USA

2999. **Vernotte, P., Natural convection around a sphere** (in French), *C. R. Acad. Sci. Paris* **237,** 21, 1312–1314, Nov. 1953.

Study of free convection in the fluid between a slightly heated sphere and a larger concentric one. Solution is given for linearized (Stokes approximation) velocity field when driving force is that due to purely conductive temperature field. Pertinent remarks are made on higher-order approximations.

S. Corrsin, USA

3000. **Johnson, H. A., Hartnett, J. P., and Clabaugh, W. J., Heat transfer to lead-bismuth and mercury in laminar and transition pipe flow,** *Trans. ASME* **76,** 4, 513–517, May 1954.

Experimental heat-transfer results in the range of Reynolds number from 1000 to 10,000 are reported for the two liquid metals. When correlated on a Nusselt-Peclet modulus basis, results are represented by a single curve with a maximum deviation of 20%. Nusselt values are considerably lower than expected from theory, and no basic change in heat-transfer performance is found in the transition region. After investigating various possible causes for the discrepancy between theory and experiments, authors state that a distortion of velocity profile from parabolic distribution may be a contributing factor.

H. Tamaki, Japan

3001. **Kaye, J., Survey of friction coefficients, recovery factors, and heat-transfer coefficients for supersonic flow,** *J. aero. Sci.* **21,** 2, 117–129, Feb. 1954.

A brief survey is presented of the progress made in the last four years on theoretical and experimental work on friction coefficients, recovery factors, and heat-transfer coefficients for supersonic flow of air.

From author's summary by W. E. Moeckel, USA

3002. **Kapadnis, D. G., The effect of fluid motion on heat transmission, Part II. Determination of the forced convection constant,** *Indian J. Phys.* **27,** 11, 533–540, Nov. 1953.

Author reports on an experimental study of forced heat convection from heated cylinders, at Reynolds numbers ranging from

about 3.8×10^3 to 1.5×10^5. He finds a fairly satisfactory agreement with the theoretical formula based on dimensional considerations. A. von Baranoff, France

3003. Delavault, H., On a heat-transfer problem and its solution by aid of Fourier and Laplace transform (in French), *C. R. Acad. Sci. Paris* **237,** 18, 1067–1068, Nov. 1953.

A mathematical paper. The equation $\nabla^2 f - \partial f/\partial t = 0$ is solved, using transforms. D. ter Haar, Scotland

3004. Tifford, A. N., and Chu, S. T., On asymptotic solutions for the heat transfer at varying wall temperatures in a laminar boundary layer with Hartree's velocity profiles, *J. aero. Sci.* **20,** 9, 643–644, Sept. 1953.

3005. Space heating with solar energy, Proc. of a Course-Symposium, M.I.T., 1950. Published 1954 by Albert Farwell Bemis Foundation, M.I.T., 161 pp., 139 illus. and diagrams. $2.85.

Although appearing three years after the Symposium, this collection of papers contains a wealth of information of interest to architects, builders, heating engineers, manufacturers, and home owners. Of particular value as reference material are papers on the performance of solar collectors (H. C. Hottel and G. O. G. Löf), properties of surfaces and diathermanous materials (A. G. H. Dietz), and the performance of solar houses (A. L. Hesselschwerdt, G. O. G. Löf, and M. Telkes). Hottel presents in detail a rigorous method for calculating the performance of any kind of solar collector using measured solar radiation data for the location in question and known properties of the materials used in the construction of the collector. Löf presents results of extensive tests on all-glass solar collectors. Hesselschwerdt presents results of a three-years' test on an occupied, solar-heated residence in Cambridge, Mass. Other topics covered include solar radiation and climatic factors, architectural and engineering design problems, heat storage, and energy-transport problems, as associated with solar heating. A. Whillier, USA

3006. Conn, W. M., Recent progress in solar furnaces for high-temperature research and development work, *J. Franklin Inst.* **257,** 1, 1–12, Jan. 1954.

Relative advantages and disadvantages, and fields of study likely to find greatest application, of solar furnaces for attaining high temperatures are discussed. Solar furnaces are best suited to research and development work where high temperatures in a pure atmosphere are needed; high cost precludes their use for solar power generation. Characteristic data for 10 modern solar furnaces that have actually been used and a compilation of factors entering into the design of experimental furnaces are presented. Author describes the equipment used in one installation to control temperature of specimen being heated, and an ingenious device that permits measurement of the temperature of the specimen by an optical pyrometer. The latter device eliminates solar radiation *reflected* by the specimen so that the pyrometer receives only radiation *emitted* by the specimen. Measurement of temperature of a specimen of unknown emissivity is discussed. A. Whillier, USA

3007. Conn, W. M., and Braught, G., Separation of incident and emitted radiations in a solar furnace by means of rotating sectors, *J. opt. Soc. Amer.* **44,** 1, 45–47, Jan. 1954.

Use of optical methods for measurement of temperature of specimens heated by radiation in solar furnaces requires that all reflected solar radiation be prevented from reaching the optical pyrometer. Authors describe a device for this purpose consisting of two disks, one located near the pyrometer and the other of special shape located near the hot specimen, which rotate at about 2500 rpm. Once every revolution the disks simultaneously intercept the incident solar radiation while exposing the pyrometer to the radiation emitted by the specimen. The method is usable in any situation where it is desired to intercept radiation incident on a target for brief periods so that emitted radiation may be measured. A. Whillier, USA

3008. Spalding, D. B., Mass transfer from a laminar stream to a flat plate, *Proc. roy. Soc. Lond.* (*A*) **221,** 1144, 100–104, Jan. 1954.

The Kármán-Pohlhausen-Kroujilne method is used to calculate the mass-transfer rate from a laminar stream to a flat plate for fluids whose diffusion coefficients do not vary greatly from their kinematic viscosities. Aerodynamically, the problem is similar to that of a laminar boundary layer with suction distributed in proportion to the reciprocal of the square root of the distance from the leading edge. J. M. DallaValle, USA

3009. Woodcock, A. H., Kientzler, C. F., Arons, A. B., and Blanchard, D. C., Giant condensation nuclei from bursting bubbles, *Nature,* **172,** 4390, 1144–1145, Dec. 1953.

3010. Braddon, G., and Waitkus, J., Design and operation of high recovery regenerative-type air preheaters, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—F-22, 17 pp.

3011. Hemeon, J. R., Design of hydraulic equipment for heat dissipation, ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-177, 12 pp.

3012. Cavallaro, L., Indelli, A., and Pancaldi, G., On some improvements on a cryoscopic precision apparatus and on the control of a thermocouple (in Italian), *Ric. sci.* **23,** 12, 2237–2243, Dec. 1953.

Combustion

(See also Revs. 2960, 3045)

3013. Gross, R. A., and Esch, R., Low-speed combustion aerodynamics, *Jet Propulsion* **24,** 2, 95–101, Mar.-Apr. 1954.

Article presents a detailed mathematical analysis of a two-dimensional, low-speed, inviscid, steady flow field containing a finite straight-line discontinuity which the authors use as a model of a combustion wave (English nomenclature = flame front). The reviewer believes that the physical assumptions made are reasonable for laminar flames at other than subatmospheric pressures. Starting in the usual way in aerodynamic flow calculations with the principles of conservation of mass and momentum, authors develop the fundamental equations of motion, energy, and entropy change and deduce, using a theorem by L. Crocco, that the product flow field is irrotational and that therefore the methods of classical potential theory may be used. Field equations for the two cases of a straight-line source sheet and a V-sheet are evaluated in terms of the stream function ψ, and one numerical solution is presented graphically for each case employing a density ratio 7. Agreement between experimental and theoretical flame shapes for the V-flame case is shown to be good for small values of the ratio of flame speed to fluid velocity at infinity, but poor at higher values.

In reviewer's opinion, one of the most important aspects of the work is that it suggests what nondimensional parameters are important in such "wall-less" aerothermodynamic problems, and the reviewer believes that these fundamental studies are well worth pursuing and ultimately extending to the cases in which walls are present. B. P. Mullins, England

3014. **Thring, M. W., and Newby, M. P., Combustion length of enclosed turbulent jet flames,** Fourth Symp. (International) on Combustion, 789–796, 1953; Baltimore, Md., Williams & Wilkins.

In the present interesting paper, similarity criteria are developed, and calculations given, for predicting from small-scale cold-model systems the combustion pattern in flames in flame-heated systems. Since in large flames this combustion pattern is predominantly determined by turbulent mixing, the problem is reduced to the question of whether it is possible to predict from cold models the mixing pattern in hot burning jets. It is shown that, in first approximation, this appears possible and that flow and concentration patterns as measured in isothermal free jets may be successfully applied to that first part of an enclosed jet where it is assumed that all the available air is entrained by the jet, and can be used for estimating the total amount of recirculated fluid. Apart from the obvious geometrical groups, important groups for similarity appear to be m_0/m_a, ρ_f/ρ_0, and $m_0/L(\rho_f G_0)^{1/2}$, where m_0 = mass flow rate of nozzle fluid, m_a = ditto of ambient fluid, ρ_f density of flame gases at their actual temperature, ρ_0 that of the nozzle fluid, G_0 jet momentum, and L characteristic length. J. O. Hinze, Holland

3015. **Fabri, J., Aerothermodynamic study of combustion** (in French), Colloquium, AGARD, Cambridge Univ., Dec. 7–11, 1953; Selected combustion problems, fundamentals and aeronautical applications, London, Butterworths Publications, Ltd., 1954, viii + 534 pp., 42–58.

The notion of a "global" or rate-controlling reaction, and of the corresponding reaction rate, is defined from the point of view of aerodynamics. One can in this manner distinguish between low velocity propagation or deflagration, on the one hand, and detonation waves on the other hand. For the former, one obtains from the equations of aerothermodynamics the eigenvalue of the propagation velocity; the methods used are more or less approximate, depending on whether one desires a formal representation or a mathematically exact solution. Knowledge of the flame structure requires specification of the conditions for upstream of the reaction zone, although the spatial distribution of velocities and temperatures are actually only very weakly dependent on these. For detonation, results are obtained more easily than for deflagration. Finally, the study of one-dimensional flames is extended to real laminar flames. It is shown, in particular, that the viscosity of the flowing gases is one of the causes of the quenching of the flame in the vicinity of the wall.

From author's summary by P. Laffitte, France

3016. **Karlovitz, B., A turbulent flame theory derived from experiments,** Colloquium, AGARD, Cambridge Univ., Dec. 7–11, 1953; Selected combustion problems, fundamentals and aeronautical applications, London, Buttersworths Publications, Ltd., 1954, viii + 534 pp., 248–262, 1 plate.

Title seems misleading to the reviewer. A flame theory is developed on the basis of the statistical theory of turbulence, not from experiments. The theory relates turbulent flame velocity to the intensity of turbulence and the laminar flame velocity. On the basis of the turbulent intensity of the unburned gas approaching the flame front, the theory predicts turbulent flame velocities much lower than experimentally measured ones. A relation for estimating flame-generated turbulence is derived. Values of the intensity of flame-generated turbulence thus calculated are in fairly good agreement with values calculated from the flame theory on the basis of flame velocities deduced from the shape of experimental flames.

An equation is derived relating the thickness of the turbulent flame brush to the scale of turbulence and the laminar and turbulent flame velocities. This equation is used to estimate the scale of turbulence at various distances from the burner. Values of the turbulent brush thickness are measured with an electronic probe whose amplified signal is used to find the flame-front-position probability vs. distance into the flame brush.

A clear and informative paper. A. W. Gessner, USA

3017. **Scurlock, A. C., and Grover, J. H., Experimental studies on turbulent flames,** Colloquium, AGARD, Cambridge Univ., Dec. 7–11, 1953; Selected combustion problems, fundamentals and aeronautical applications, London, Butterworths Publications, Ltd., 1954, viii + 534 pp., 215–247, 2 plates.

The length of turbulent diffusion flames is controlled by eddy mixing of fuel and oxidant. Theory predicts that it should be independent of the fuel velocity at the burner port. This is borne out by experiment over a sizable range of port velocity. At high port velocities, a lengthening of the flame is observed which the authors attribute to molecular diffusion limitations. They discount the possibility of chemical reaction-rate limitations because volumetric heat-release rates are low compared with some found in situations which are clearly mixing-controlled.

Turbulent flame velocity in flames propagating in homogeneous mixtures is determined by the laminar flame velocity and the increase in flame area due to wrinkling of the flame front. The factors controlling laminar flame velocity and flame turbulence causing flame-front wrinkling are considered theoretically. Experimental confirmation of the theory is only fair, and several refinements in the theory are suggested.

Reviewer considers this an interesting survey of work done by others and a valuable contribution to the understanding of turbulent flames by the authors. A. W. Gessner, USA

3018. **Cude, A. L., The length of oil and gas flames. Extension of free flame relationships to practical conditions,** *J. Iron Steel Inst.* **176,** part 3, 270–273, Mar. 1954.

A new flame-length equation is given: $L = k(1 + r_t)(qs'/u)^{1/2}$, where L is flame length, k empirical dimensional constant, r_t stoichiometric air requirement of the fuel (lb air/lb fuel), q volumetric flow rate of fuel, s' jet fluid density at nozzle, and u jet fluid velocity at nozzle, Experimental measurements with city gas diluted in varying degrees with N_2 confirm the validity of the equation which, the author feels, applies to a wide variety of liquid and gaseous fuels.

Reviewer believes this claim to be too optimistic. The effects of varying adiabatic flame temperature, stoichiometric air requirement, and the mole ratio of products to reactants, all of which were simultaneously varied by dilution with N_2, ought to be separately studied before a wide applicability of the equation can be claimed.

The effects on flame length of limited excess air and momentum of the air stream are described. Observations on interference from chamber walls on straight and swirling flames are also reported.

The total lack of an attempt at a deeper understanding of the situation and the narrow scope of the paper are disappointing.

A. W. Gessner, USA

3019. Knox, J. H., and Norrish, R. G. W., Low temperature oxidation and cool flames of propane, *Proc. roy. Soc. Lond.* (*A*) **221,** 1145, 151–169, Jan. 1954.

A detailed analytical study of the cool-flame oxidation of propane has been carried out using a continuous-flow technique with a view to the further elucidation of the mechanism of the low-temperature oxidation of hydrocarbons. The formation of the three theoretically possible aldehydes has been demonstrated and the initially formed peroxide shown to be hydrogen peroxide. Measurements of the yields of the different products formed under varying conditions of temperature, composition, and time of contact have been made and correlated with measurements of the luminous intensity and temperature of the flame.

The results confirm the earlier conclusions of Norrish (1948) that aldehydes are the important branching agents in the temperature range of 300 to 400 C, and a detailed scheme based on that proposed earlier has been developed to account for the observations. The scheme has further been shown to allow of a simple explanation of the origin of the periodic character of the cool flame in terms of the thermal instability of the normal slow reaction. From authors' summary

3020. Yampolsky, J., and Price, C. F., Closed-vessel hydrogen-air explosions at high pressures, Fourth Symp. (International) on Combustion, 384–386, 1953; Baltimore, Md., Williams and Wilkins.

The burning velocity of hydrogen at various concentrations in air is calculated for pressures up to 13,000 psi from the pressure-time curves of radial explosions in a 3-inch diam sphere at 104 atm initial pressure. It appears that the burning velocity decreases with increasing pressure, but the heat loss to the walls, which may account for part or all of this effect, has not yet been taken into account. A. G. Cattaneo, USA

3021. Spalding, D. B., Combustion of a single droplet and of a fuel spray, Colloquium, AGARD, Cambridge Univ., Dec. 7–11, 1953; Selected combustion problems, fundamentals and aeronautical applications, London, Butterworths Publications, Ltd., 1954, viii + 534 pp., 340–352.

A review of the current status of the theory of burning of liquid fuels as single drops and as sprays. The physical and chemical aspects of liquid fuel burning are shown to be capable of separate treatment. The burning rate of a single drop can be predicted with acceptable precision if the nature of the fuel and atmosphere and of their relative motion is specified. The relative motion within a spray is too complex to permit analysis yet, and it is not certain whether droplet burning or jet mixing controls combustion in a gas turbine. It appears that the extinction condition is related to the laminar flame speed but not to the spontaneous ignition characteristics of the fuel.

From author's summary by M. Gerstein, USA

3022. Wisniowski, H. U., Preliminary experimental investigation of howling in reheat combustion chambers, *Nat. aero. Establ. Canada* LR-84, 31 pp., Sept. 1953.

In commencing this investigation, howling combustion was considered to be related to the phenomenon known in acoustics as "singing flames," and first experiments were made with a gas burner on pipes of several dimensions. Later, a small-scale rig (diameter, 5 in.), simulating conditions in a turbojet engine with reheat, was used.

The effect of many factors on howling was investigated. It was found that howling was caused by a standing longitudinal wave. Unstable combustion was assumed as the origin of this oscillation.

From author's summary

3023. Shorin, S. N., and Pravoverov, K. N., Heat exchange in cooled combustion chambers during the combustion of gases (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 8, 1122–1129, Aug. 1953.

Experimental calorimetric research and measurements, related to radiant heat-transfer theory, prove that specific heat delivery in water-walled, gas- or liquid-fuel-fired combustion chambers can be increased up to three times from values obtained with volume diffused flames. This is achieved by developing indirect radiating baffles, impinging the flame path and properly facing the cold walls. Stacks of refractory plates or grids of heat-resistant alloys are suggested. Such also act as aids to complete combustion by inducing turbulence and becoming incandescent igniters.

Reviewer believes that principles are sound, but practical full-size applications will meet great difficulties connected with extreme high-temperature structures, increasing rapidly with the size of the combustion chamber, its temperature, and its requirements of reliable long-term service. B. Posniak, USA

3024. Folliot, A., Flame studies on rotary concrete furnaces (in French), *Rev. Matér. Constr.* no. 459, 329–332, Dec. 1953.

The process by which heat is transmitted in a rotary furnace, a study almost impossible to undertake by a direct method, must be analogous to that taking place in the steel and glass furnace. The experiments carried out by the Ijmuiden Committee, though not dealing with powdered coal, will, no doubt, be of use, even in this case, in controlling the formation of rings and the protecting layer of the firing zone, through action of the factors of combustion. Among these latter, the temperature of the preheated air and the fineness of the fuel are very important. But for this latter, calculations are disappointing, and the actual measuring done at Ijmuiden will serve to determine its optimum.

The author suggests, moreover, some subjects for study: role of convection, effect of the spectral make-up of the flame and the nature of absorbent materials, oxygenation of the combustion air. From author's summary

3025. Bowden, A. T., Draper, P., and Rowling, H., The problem of fuel-oil ash deposition in open-cycle gas turbines, *Proc. Instn. mech. Engrs.* (*A*) **167,** 3, 291–305, 4 plates, 1953.

The loss of power from fuel-oil ash deposition on the turbine blades limits the use of boiler oil fuels for open-cycle gas turbines, thus restricting their more widespread application.

The nature and occurrence of the ash-forming constituents are discussed together with the possibilities of their removal from the oil. It is concluded that much basic information is lacking and more experimental work is required. Some data are taken from studies on a Parsons experimental gas turbine; new data were obtained from a laboratory-type equipment that included a combustion chamber and a row of blades, designed to study the problem under various combustion conditions.

It was found that, by controlling the burner atomization to produce an oil droplet of a size so that each droplet would burn down and leave the combustion chamber as a hard, dry, carbon particle containing a high proportion of the ash, the deposition of ash was greatly reduced while the unburned carbon loss was less than 1%. Information is given on the use of additives in reducing ash deposition.

The experimental work presents a control scheme that appears worth while for further consideration for testing on gas-turbine operation. J. F. Barkley, USA

Acoustics

(See also Revs. 2758, 2761)

3026. **Copson, E. T., The reflexion of sound waves of finite amplitude by a rigid wall,** *Proc. roy. Soc. Lond.* (*A*) **222,** 1149, 254–261, Mar. 1954.

A polytropic gas of adiabatic exponent 5/3 fills the half-space on one side of a rigid plane wall of infinite extent. Initially the gas is at rest and its density is proportional to $x^{3/2}$, where x is the distance from the wall. Taking into account the initial condition only and neglecting the boundary condition $u = 0$ when $x = 0$ (u is the velocity of the gas), a solution is obtained which is identical to that of the problem of the expansion of a gas cloud into a vacuum (see following review). On the other hand, a solution is found satisfying the boundary conditions, but not the initial condition. It proves to be impossible to patch these two analytical solutions continuously together along a suitably chosen curve $x = \xi(t)$. Instead, a discontinuous solution is derived which satisfies the shock-wave conditions along the shock front $x = \xi(t)$. Other solutions might be obtained if more shock waves are introduced.

It is shown that the shock wave performs a uniformly accelerated motion starting at $x = 0$, $t = 0$. The greatest change in pressure takes place across the shock discontinuity and the variation between the shock and the wall is small. The problem has been solved completely without recourse to numerical integration. A. I. van de Vooren, Netherlands

3027. **Copson, E. T., On sound waves of finite amplitude,** *Proc. roy. Soc. Lond.* (*A*) **216,** 1127, 539–547, Feb. 1953.

An analytical solution of Riemann's equations for the one-dimensional propagation of sound waves of finite amplitude in a gas obeying the adiabatic law $p = kp^{\gamma}$ is obtained for any value of the parameter γ. The solution is in the form of a complex integral involving an arbitrary function which is found from the initial conditions by solving a generalization of Abel's integral equation. The results are applied to the problem of the expansion of a gas cloud into a vacuum.

From author's summary by A. I. van de Vooren, Netherlands

3028. **Zatzkis, H., Sound field of a moving cylinder and a moving sphere,** *J. acoust. Soc. Amer.* **26,** 2, 169–173, Mar. 1954.

Author, extending a previous paper [AMR **7,** Rev. 950], claims to calculate the sound field of a moving cylinder and sphere by solving the following boundary-value problem: The partial differential equation which describes the sound propagation in a perfect gas at rest, in a coordinate system which moves uniformly with the sound source, is solved with the velocity potential F given on the surface of the sphere and the cylinder, respectively. This is done by standard methods of series development.

It is obvious for two reasons that the problem solved in this paper is by no means the acoustically interesting question. (1) For an acoustic vibrator, $\partial F/\partial n$ is prescribed as boundary condition on the surface. Author's assumption that the velocity potential is given simplifies the problem considerably; however, it is neither clear nor discussed in the paper how this type of an acoustic source should be physically realized. (F is not even the sound pressure, as in ordinary acoustics.) (2) No word is said on the influence of the motion of the medium around the sphere or the cylinder. Rather, author tacitly assumes the source penetrated by the gas, so that it is not set in motion by the moving source. This seems a very questionable assumption for sources of sufficiently large dimensions.

In the literature citations one misses, among others, the mention of Blokhintzev [*title source* **18,** p. 322, 1946] or his book, "The acoustics of an inhomogeneous moving medium," Moscow, 1946, Engl. translation by Research Analysis Group, Brown Univ., Providence, R. I., 1952, and any reference to the large number of papers dealing with the oscillating airfoil. See, e.g., Garrick [AMR **5,** pp. 89–90] and, in particular, E. Reissner [AMR **4,** Rev. 3617] or Timman [AMR **4,** Rev. 2142; **5,** Rev. 1475] who use the method of series development for a very similar problem. H. L. Oestreicher, USA

3029. **Kornhauser, E. T., Ray theory for moving fluids,** *J. acoust. Soc. Amer.* **25,** 5, 945–949, Sept. 1953.

In this paper it is pointed out that Heller's generalized eikonal equation for propagation of weak acoustic shocks in a moving inhomogeneous fluid (see following review) may be obtained as a very simple extension of the ordinary case of ray theory. Elementary solutions for media with a uniform velocity are discussed. Finally, a generalized form of Snell's law is derived, and it is specialized in three separate ways to yield formulas useful for solution of problems in stratified media. Examples of its application are given. Author's results may be useful not only in the rigorous calculation of propagation of discontinuities, but also in an approximative treatment of the propagation of continuous waves (if the wave length is small enough to permit a ray approximation). M. Schäfer, Germany

3030. **Heller, G. S., Propagation of acoustic discontinuities in an inhomogeneous moving liquid medium,** *J. acoust. Soc. Amer.* **25,** 5, 950–951, Sept. 1953.

In his well-known treatise on jump or discontinuity phenomena, Christoffel has shown that if the time derivatives of velocity and pressure in a liquid are discontinuous on a surface (e.g., explosive shocks), then that surface must propagate in accordance with the ray-theory governing eikonal equation $|\nabla S|^2 = n^2$. (Here $t = c_0^{-1}S(x, y, z)$ is the equation of the surface at time t, c_0 velocity of propagation at some reference position in the liquid, n index of refraction referred to c_0.) This derivation is based on the equations for infinitesimal acoustic waves

$$\rho_0 \partial \mathbf{V}/\partial t = -\nabla P,\ \partial P/\partial t = -\rho_0 \nabla \cdot \mathbf{V},\ P - P_0 = c^2(\rho - \rho_0)$$

($\mathbf{V}$, ρ, P particle velocity, density, pressure, respectively; P_0, ρ_0 mean pressure and density, c velocity of propagation in the medium).

In this paper, author shows that under more general conditions (inhomogeneous, nonstationary fluid), using the equations of motion and of continuity in their exact form

$$\rho D\mathbf{V}/Dt = -\nabla P,\ D\rho/Dt = -\rho \nabla \cdot \mathbf{V}$$

and assuming the pressure-density-relation

$$DP/Dt = c^2 D\rho/Dt\ (D/Dt = \partial/\partial t + \mathbf{V} \cdot \nabla)$$

the propagation is according to the generalized eikonal equation

$$|\Delta S|^2 = n^2(1 - c_0^{-1}\mathbf{V} \cdot \nabla S)^2$$

To a first approximation (infinitesimal acoustic waves) $\mathbf{V}$ may be replaced by the medium-velocity $\mathbf{V}_0$. M. Schäfer, Germany

3031. **Kishimoto, T., and Nomoto, O., Parts I, II; Nomoto, O., and Kishimoto, T., Part III, On molecular sound velocity of liquids,** *J. phys. Soc. Japan* **9,** 1, 59–77, Jan.-Feb. 1954.

Authors employ the Lennard-Jones and Devonshire equation of state as modified by Wentorf, Buehler, Hirschfelder and Curtiss [*J. chem. Phys.* **18,** 11, 1484–1500, Nov. 1950] to compute the

ratio $(1/\beta_s)(\partial\beta_s/\partial T)_p/\alpha$, where β_s is the adiabatic compressibility of the liquid and α its temperature coefficient of expansion. Values of from 6.0 to 8.0 are found for several organic liquids at 0.9 times the boiling point temperature T_b in fair agreement with experimental results and with an empirical rule of Rao, which predicts the ratio 7.

Similar calculations show that α as well as $(1/\beta_T)(\partial\beta_T/\partial T)_p$ and $(1/v)(\partial v/\partial T)_p$ are proportional to $1/T_b$ at temperatures near $0.9T_b$, where β_T is the isothermal compressibility of the liquid and v is the speed of sound in it. The predicted straight-line relationships are in agreement with experimental data for many organic liquids and liquefied gases, but the experimental proportionality constants are approximately three times as great as the theoretical values.

Finally, an expression for the molecular sound velocity, (M/ρ)-$v^{1/3}$, where M is the molecular weight of the liquid and ρ is its density, is deduced, which is of the same form as Rao's empirical relation [*J. chem. Phys.* **14,** 11, p. 699, Nov. 1946], although the theoretical proportionality factor is about 75% larger than the experimental value. R. Heller, USA

3032. Lucas, R., and Grossetti, E., Mechanical action upon obstacles exposed to ultrasonics (in French), *C. R. Acad. Sci. Paris* **238,** 4, 458–459, Jan. 1954.

When a plane wave of sound is reflected from a plane wall, a radiation pressure is exerted having a normal component N and a tangential component T equal to

$$N = (1 + r)w\cos^2 i;\quad T = (1 - r)w\sin i\cos i \qquad [1]$$

where i designates the angle of incidence, w the energy density, and r the reflection constant. These laws have been verified by using a torsion balance attached to various shaped obstacles and different reflecting conditions. Obstacles used were a plane disk, a cone of revolution, and a sphere. The frequency used was 1.496 megacycles and the energy density 3.27 ergs/cm³. The results checked Eq. [1] within a few per cent.

W. P. Mason, USA

3033. Westervelt, P. J., Acoustic streaming near a small obstacle, *J. acoust. Soc. Amer.* **24,** 6, p. 1123, Nov. 1953.

Steady rotational flow is known to occur in the vicinity of a smooth rigid object oscillating to and fro in a viscous incompressible fluid. For a small oscillation amplitude, the steady flow is shown theoretically to be invariant to the coordinate transformation which renders the object stationary.

From author's summary by K. M. Siegel, USA

3034. Lambert, R. F., A study of the factors influencing the damping of an acoustical cavity resonator, *J. acoust. Soc. Amer.* **24,** 6, 1068–1083, Nov. 1953.

An analysis of losses in propagation of acoustic energy in the 0, 1 transverse mode in a circular pipe. Losses separated into (1) boundary-layer losses due to viscosity and heat conduction, (2) anomalous absorption due to thermal relaxation, and (3) pipe-wall-vibration losses. Shortcomings of previous mathematical and experimental studies are reviewed. (Excellent bibliography is included.) Author presents his more accurate data for the frequency range of approximately 3500–6000 cps. Data are taken in steel tubing $2^1/_4$-in. ID and $^1/_4$-in. wall. Wall-vibration losses are determined for thicknesses down to $^1/_{16}$-in. For $^1/_4$-in. walls, boundary-layer losses were largest, wall-vibration losses least, although measurably appreciable.

W. W. Soroka, USA

3035. Weston, D. E., The theory of the propagation of plane sound waves in tubes, *Proc. phys. Soc. Lond.* (*B*) **66,** 404, 695–709, Aug. 1953.

The theory of the propagation of sound waves of the principal mode in cylindrical tubes over a wide range of diameters is investigated. The three following types of motion as set forth in Kirchhoff's theory are considered: (1) Narrow tube—radius very small and frequency low; (2) wide tube—sound energy diffused over cross section of tube; (3) very wide tube differing from type (2) mainly in that sound energy is concentrated near walls. Resistance concept for narrow tubes and boundary-layer concept for wide tubes are considered and the more complete theory is developed. The application to Lawley's recent results on sound attenuation in oxygen at 120 kcps in a tube of 1.5-cm diam at pressures from 5 to 130 mm Hg is discussed.

Marie Goyer, England

3036. Weston, D. E., Part I; Weston, D. E., and Campbell, I. D., Part II, Experiments on the propagation of plane sound waves in tubes, *Proc. phys. Soc. Lond.* (*B*) **66,** 405, part 9, 769–774, Sept. 1953.

Part 1. Adiabatic region. Using a magnetostriction interferometer, sound propagation measurements were made in gases with tubes of glass, stainless steel, and cupro nickel; tubes of radius 0.013 cm upward were used with sound frequencies between 10 and 20 kcps. Only a brief description is given of the apparatus, and readers are referred to previous work. Graphs giving the results obtained for attenuation in glass and cupro-nickel tubes for the two extreme frequencies (10067 and 19784 cps) show good agreement between experiment and the modified Kirchhoff values of the velocity reduction in air for different sizes of glass tubes at a frequency of 1754 cps, and of the attenuation in air, argon, and nitrogen for the same frequency in a Veridia glass tube of radius 0.0498 cm.

Part 2. Transition region. Sound-velocity and attenuation measurements were made with tubes of radius of about 0.02 cm containing air at normal pressure and frequencies varying from 70 to 8000 cps, the source and detector of the interferometer being located at opposite ends of the tube. The results for cupro-nickel and stainless-steel tubes show that the values for the velocity are in good agreement with the theory, whereas the experimental results for the attenuation are slightly higher than the calculated values. Marie Goyer, England

3037. Epstein, P. S., and Carhart, R. R., The absorption of sound in suspensions and emulsions, I, Water fog in air, *J. acoust. Soc. Amer.* **25,** 3, 553–565, May 1953.

Authors approximate suspended matter by fluid spheres. They calculate the diffraction problem for the spheres assumed to be immersed in viscous fluid medium. Viscous and thermal effects are taken into account in evaluating a propagation constant for sound waves. Authors check their predictions for water droplets in air and find reasonable agreement with Knudsen's absorption measurements for water fog.

O. K. Mawardi, USA

3038. Kharanen, V. Y., Sound propagation in a medium with random fluctuations of the refractive index, Nat. Sci. Found. tr.-8, June 1953; *Dokladi Akad. Nauk SSSR* (*N.S.*) **88,** 2, 253–256, Jan. 1953.

Author has examined the problem of sound propagation in a medium with random fluctuations of refractive index, the deviation of the refractive coefficient from unity being small. Formulas have been deduced for finding out the distance for which a sound

ray emitted horizontally will remain horizontal. The whole treatment is based upon the ray approximation, but limits of applicability of the ray picture are not discussed. These calculations are of great interest in sound propagation in the surface layer of the sea. G. S. Verma, India

3039. **Chetayev, D. N., Acoustic resistance of a moving plane emitter,** Nat. Sci. Found. tr-89, 1954; *Dokladi Akad. Nauk SSSR* (*N.S.*) **90,** 3, 355–358, May 1953.

The well-known expression for the acoustic radiation impedance of a circular piston in an infinite wall is extended to the case when the piston radiates into a medium which is moving with a constant velocity in a direction normal to the infinite plane. The analysis is essentially an application of the generalized Kirchhoff theory for a moving medium given by Blokhintzev in his book "Acoustics: Sound propagation in an inhomogeneous moving medium." Numerical values for the radiation impedance in a particular case are presented in tabular form as a function of frequency. U. Ingard, USA

3040. **Meyer, E., and Skudrzyk, E., Acoustical properties of gas bubbles in water** (in German), *Akust. Beihefte* no. 3, 434–440, 1953.

Sound passing through a mixture of gas bubbles and water is markedly attenuated at the resonant frequency of the bubbles. Principal factors are radiation resistance and heat-conduction loss. Attenuation at low concentrations and frequencies below bubble resonant frequency varies as product of gas concentration and square of frequency; at resonance, as gas concentration; above resonance, as product of gas concentration, fourth power of resonant frequency, and inversely as square of frequency. Experimental results confirm the order of magnitude of theoretical predictions. Principal difficulty is to produce bubbles of uniform size. V. Salmon, USA

3041. **Hodgkinson, T. G., The response of a spherical fluid particle suspended in air to irradiation with sound at the natural frequency of the particle,** *Acustica* **3,** 6, 383–390, 1953.

A spherical drop of liquid is considered as suspended in a gaseous medium, and as irradiated with a sound wave, a component frequency of which compares with a natural frequency of the spherical drop. Emphasis is placed upon the second mode, as the first distortional mode of vibration of the drop, and for this mode, this particle velocity on the surface of the drop is determined as a function of the densities and viscosities of the liquid and the gas, of the surface tension of the gas-liquid surface, and of the velocity potential of the component frequency of the irradiating wave.

It is shown that for very large drop sizes, the particle velocity in the incident wave, required to produce stress in the surface of the drop compared with the surface tension of the liquid-gas surface, is almost independent of the value of this surface tension.

Examples are calculated of the field energy required for a 130μm diameter particle and for an 800μm particle at their natural frequencies in the second mode, and comparison is made with the energy available in the sound field of a particular siren. From author's summary

3042. **Janssen, J. H., A method of measuring the velocity of sound in a few grams of a liquid,** *Acustica* **3,** 6, 391–394, 1953.

A slight modification of the electrodynamical sound generator of St. Clair permits determination of the resonance frequency of the free-free bar with and without a liquid column on top of it.

The velocity of sound of the liquid follows from a very simple formula, taking account of the small quantity of the liquid. The height of the column is about one quarter of a wave length (2.5 cm for 10 kcps). It is thought that the accuracy may be better than 0.1%. From author's summary

3043. **Lee, R., Free field measurements of sound radiated by subsonic air jets,** *David W. Taylor Mod. Basin Rep.* 868, 15 pp., Dec. 1953.

Noise level, frequency range, and directional patterns of air jets of $^1/_2$-in. and $^5/_8$-in. diameter at the nozzle exit were determined. The jet speeds varied between 250 and 1000 fps. In agreement with tests at other institutions, the results show that the directive pattern of the noise is a function of the noise frequency and jet velocity and size.

An increase in jet velocity results in concentration of the noise along the jet axis. The angle of maximum sound pressure increases relative to the direction of flow with increasing sound frequency. The tests are compared with Lighthill's theory and with previous tests. Some discrepancies can be attributed to differences in the thickness of the shear layer due to different nozzle length-diameter ratios. The acoustic power was found to be proportional to the 6.4th power of the jet velocity, compared with the 8th power predicted by Lighthill. This discrepancy was explained by an insensitivity of the microphone to a portion of the frequency range.

In general, the report is a useful contribution to the solution of the noise problem of gas jets. H. J. Ramm, USA

3044. **Walters, A. G., The noise from aircraft travelling with velocities greater than that of sound,** *J. roy. aero. Soc.* **57,** 515, 719–720, Nov. 1953.

3045. **Esclangon, E., Waves and ballistic detonations caused by airplanes and projectiles** (in French), *Mém. Artill. fr.* **27,** 4, 947–972, 1953.

Expository article reviews old French ordnance observations of acoustic phenomena associated with supersonic projectiles. Most extensive work was inspired by need to distinguish between pressure pulse from bow wave and that due to muzzle blast. Latter was required for acoustic ranging in 1914–1918. Analogy between acoustics of projectiles and aircraft is discussed; e.g., bangs similar to but not as intense as those for supersonic aircraft were observed as projectiles twice accelerated through speed of sound in high angle fire. Also considered is geometry of expanding shock system, virtually a sound wave far from projectile. Normals to wave form a family of sound cones with vertices on trajectory. Envelope of cones is focal surface along which wave's edge of regression travels and beyond which projectile's sound does not penetrate. J. H. Giese, USA

Ballistics, Detonics (Explosions)

3046. **McShane, E. J., Kelley, J. L., and Reno, F. V., Exterior ballistics,** Univ. of Denver Press, 1953, xiv + 834 pp. $12.50.

To describe this book for the professional would be entirely wasteful. Because of its well-defined appeal, its unique parentage, and the lack of a competitive title, it already has reached its readers, who by now know its indispensability and its virtues. This review may limit itself to critical remarks.

The presentation used in the rough-and-tumble of wartime reports may be incompatible with the dignity and performance of an academic volume. This one is the first to present the modern

theory of spinning-projectile motion, and will, presumably, freeze the usage in this field. But it seems that some decade-old report material went into the book unpolished, and even undusted. For one thing, the book did not seize this unique chance to replace the current (and haphazard) notation for the aerodynamic coefficients by a rational and symmetric one which would give some grace and structure to the equations of motion, and some relief to the reader's memory. Each of the eight cross coefficients represents either a force (f) or a moment (ϕ); each is due either to axial speed u_1 or to axial spin (ω_1); and each is due to cross velocity (say, u) or to cross spin (say, ω). This makes such a symbol as, say, $\phi_{\omega u}$ immediately recognizable as "the Magnus cross moment due to cross velocity," in the terminology of Nielsen and Synge. More than a matter of the finish is the fact that only one perfunctory paragraph (page 610) is offered to justify the vital (and admittedly debatable) order-of-magnitude assumptions, "wrenching" the equations of angular motion into some kind of integrability. This stands in curious contrast with the occasionally pedantic rigor of the mathematical prerequisites offered (nearly 200 pages).

Exterior ballistics is a strange doctrine of many methods and few general results of physical interest. It is hardly fascinating to those without vested interest in it. The authors deserve special gratitude for their real effort to enliven the exposition.

A. W. Wundheiler, USA

3047. Powley, H. S., Rapid estimation method for long-pointed projectile trajectories, *J. Franklin Inst.* **257,** 3, 221–227, Mar. 1954.

Many problems in shooting would be greatly simplified if one or two points could be determined on a trajectory by experimental shooting and then the rest of the trajectory became known. Alternately, if one or two points on a trajectory are determined by theory, and if the rest of the trajectory becomes available in simple fashion, the practical benefits would be appreciable. The present paper shows one means to this end.

Author noticed that when data were plotted on logarithmic paper, practically a straight line resulted. The immediate possibility became apparent that a trajectory curve might be considered, from a practical standpoint, as that from a simple exponential equation.

This brings author to the preliminary conclusion that the following equation applies to flat-base Spitzer-pointed projectiles: Drop $= kx^{2.3}$, where x is horizontal range and k numerical constant. For as good an approximation as this is, the value of k can be determined by firing for drop at two different ranges x. This having been determined, the remainder of the trajectory at other or intermediate points can be simply determined.

Thus author pretends that, within practical limits of measurement for projectiles with *long-pointed heads* at *supersonic velocities*, the downward curve of the trajectory in air from a substantially horizontal firing is directly proportional to the 2.3 power of the range. This represents a very great simplification of trajectory determinations and permits of very rapid and accurate estimations with a minimum of data. R. Sjöberg, Sweden

Soil Mechanics, Seepage

(See also Revs. 2788, 2996, 3064)

3048. Ferguson, C. K., and Klotz, J. A., Filtration from mud during drilling, *J. Petr. Technol.* **6,** 2, 30–43, Feb. 1954.

Paper describes experimental investigations conducted on a model oil well. The first part describes filter loss from several drilling muds through bore hole walls during mud circulation and drill string rotation. The effect of mud properties and drill string rotation with mud circulation is described. Filtration from a bore hole full of drilling mud, not circulating but under pressure for extended time periods, is also discussed.

The second part describes filter loss to permeable formations from beneath a drilling bit where filter cake has no opportunity to develop appreciable thickness. If potential flow theory is applied to predict filtrate invasion from this hole bottom, large invasions are calculated. But model well experimentation shows that filtrate invasion from the hole bottom is controlled by mud particles that penetrate the formation ahead of the bit. This experimentation provides data to estimate the effect of mud particle penetration on fluid loss to formation.

The third part presents an estimate of mud filtration during drilling of a well. From authors' summary

3049. Allen, T. O., and Atterbury, J. H., Jr., Effectiveness of gun perforating, *J. Petr. Technol.* **6,** 1, 34–40, Jan. 1954.

3050. Skempton, W., A foundation failure due to clay shrinkage caused by poplar trees, *Proc. Instn. civ. Engrs.*, part I **3,** 1, 66–83, 1 fig., Jan. 1954.

In 1942, serious cracking developed in the 65-ft-high wall of a theater, built in 1928, situated in north London. The foundations of the wall were at a depth of 4 ft below ground level and rested on firm clay. Investigations showed that the cause of the cracking was shrinkage resulting from drying of the clay by the roots of a row of poplars, planted in 1930, at an average distance of 35 ft from the wall. The wall was underpinned in 1947 and no subsequent movements have been observed. No cracking has occurred in a neighboring school although one wall is as close to the trees as the wall of the theater. The school has a basement, however, and the footings of the school wall nearest to the trees are at a depth of about 9 ft. The paper concludes with some suggestions for the "safe distance" from trees for buildings on shallow foundations in clay soils with a recommendation that, if homes and other small structures are to be built within this "safe distance" from trees, they should be founded on short-bored piles, unless a basement can be provided.

From author's summary by W. G. Shockley, USA

3051. Dunham, J. W., Pile foundations for buildings, *Proc. Amer. Soc. civ. Engrs.* **80,** Separ. no. 385, 21 pp., Jan. 1954.

There is derived herein a method of determining the capacities, lengths, and spacing of foundation piles which are to be driven and remain in contact with the soil and are to be loaded axially. A design procedure for application of the method and a field procedure to carry out the intent of the design are presented.

From author's summary

3052. Grandvoinnet, J., Study of power-hammer pile driving (in French), *Ann. Inst. tech. Bât. Trav. publics* **7,** 73, 21–50, Jan. 1954.

Power-hammer pile driving is a technique which, owing to its cost, improves rather slowly. While giving a documentary presentation of this problem, the author reviews a certain number of theoretical considerations concerning impact, particularly as they apply to pile-driving formulas. The latter, so often criticized, can be improved and standardized by practical measurements. Through performance of laboratory tests on scale models, it has been possible to give an accurate picture of the phenomena and to develop a method of investigation which could be used in practice. From author's summary

3053. **Johnson, S. J., Field penetration tests for selection of sheepsfoot rollers,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 363, 21 pp., Dec. 1953.

The force required to cause 0.2-in. penetration of 6 to 24 sq in. model feet into field-compacted soils is correlated with the ability of sheepsfoot roller feet to walk out. The smaller feet gave higher penetration resistances than the larger, except at high moisture content. The possibility of using the Proctor needle instead of model feet is indicated. E. S. Barber, USA

3054. **Reynolds, C. E., Loads on groups of free-standing piles,** *Concr. Constr. Engng.* **48,** 12, 373–380, Dec. 1953.

3055. **Fröhlich, O. K., On the settling of buildings combined with deviation from their originally vertical position,** *Proc. Third Inter. Conf. Soil Mech. Foundation Engng.*, Aug. 16–27, 1953, vol. I, 362–365.

Foundation science has recorded many case histories in which buildings tilted from their original vertical position as their footings settled. Underpinning has been frequently used in reconstruction work on tall, slender structures; classic examples are grain elevators, stacks or chimneys, water towers, and church steeples. Of concern in designing these foundations are methods of determining the deformation of the bearing surface of slabs and footings. The problem was solved when the distribution of vertical normal stresses over the contact surface produced identical uniform strains in both the lower mat surface and the top surface of the semi-infinite soil mass.

Equations are presented for evaluating the distribution of contact pressure, settlement, and inclination of rigid circular and infinitely long continuous footings. An experimental procedure is suggested for footings having other shape forms. Limitations of the equations when applied to practical problems include comments on (1) the practical depth limit of the upper layer of homogeneous soil, (2) plastic soil deformations in the highly stressed zones near contact surfaces at foundation rims, and (3) friction on the contact surface between the foundation and the soil. T. L. Speer, USA

3056. **Mandel, J., Consolidation of soils** (mathematical study) (in French), *Géotechnique, Lond.* **3,** 7, 287–299, Sept. 1953.

Author presents new formulas for the prediction of the settlement of a clay stratum, instead of the Terzaghi solution for the unidimensional case of a thin stratum under normal uniform pressure. This mathematical study of the problem considers immediate and delayed deformation, general form of the solution, and particular forms in the case of a concentrated force applied on the upper side of the stratum, and in the case of infinite thickness (for which the settlement tends to the Boussinesq solution). R. Spronck, Belgium

3057. **de Vries, G., A new device for measuring soil vibrations** (in French), *Rech. aéro.* no. 35, p. 53, Sept.-Oct. 1953.

3058. **Esmiol, E. E., The diversity of impervious soils used in Bureau of Reclamation earth dams,** *Proc. Third Inter. Conf. Soil Mech. Foundation Engng.*, Aug. 16–27, 1953, vol. II, 224–238.

3059. **Gruner, E., and Gruner, G., Muram and decomposed rock as construction materials for earth dams,** *Proc. Third Inter. Conf. Soil Mech. Foundation Engng.*, Aug. 16–27, 1953, vol. II, 245–248.

3060. **Muhs, H., Earth-pressure tests on a retaining wall anchored by friction** (in German), *Bautechn.-Arch.* **9,** 3–20, 1953.

A description is given of a system of bulkhead anchorage which is based on the frictional resistance of the soil on a horizontal slab, buried in the backfill. The slab is said to give a relief in earth pressure on the lower part of the bulkhead at the same time.

Small-scale tests were executed to find the most favorable position for the slab. The results of these tests were compared with the results of tests on a bulkhead without friction slab anchorage, executed with the same apparatus. Practical rules for the dimensioning of friction slabs are given. F. C. de Nie, Holland

3061. **Li, C. Y., A concept of slope design of earth dam embankment,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 327, 9 pp., Nov. 1953.

3062. **Stewart, R. C., and Weiss, S. J., Trafficability of soil as related to mobility of vehicles,** *Proc. Amer. Soc. civ. Engrs.* **79,** Separ. no. 328, 12 pp., Nov. 1953.

The following conclusions are presented: (1) Despite the fictitiousness of the classical concept of soil, the angle of internal friction and the coefficient of cohesion appear to remain the key to the prediction of vehicle performance. (2) Utilizing an effective angle of friction ϕ and an effective coefficient of cohesion c, determined on the spot, eliminates much of the error associated with considering them constants of the soil. (3) Using the effective angle of friction ϕ and an effective coefficient of coehsion c as coordinates, Drawbar-Pull charts can be prepared in advance for every self-propelled vehicle in a tactical organization. Rolling Resistance charts can be similarly prepared for every towed vehicle. (4) Upon determination of the effective ϕ and the effective c of doubtful soil, determined on the spot, utilizing field instruments such as the Soil Truss developed for this purpose, the performance of either individual vehicles or trains of vehicles can be predicted and movement of the tactical organizations can be planned accordingly. From authors' summary

3063. **Silva, F. P., Shearing strength of a soft clay deposit near Rio de Janeiro,** *Géotechnique, Lond.* **3,** 7, 300–305, Sept. 1953.

Micromeritics

3064. **Kravtchenko, J., de Saint-Marc, G. S., and Boreli, M., On the singularities of two-dimensional steady flow of liquids in porous media** (in French), *C. R. Acad. Sci. Paris* **238,** 2, 209–211, Jan. 1954.

Paper treats particularly the analytical behavior in the neighborhood of the point where a free streamline meets a line of seepage. Analysis is an elegant simplification of Polubarinova-Kochina's work ["Theory of ground water movement," Gostekhizdat, Moscow, 1952]. For further developments see "Contribution to the study of porous media" by M. Boreli [thesis, University of Grenoble, 1954]. A. Craya, France

3065. **Khudyakov, G. N., Motion of solid particles in gas suspensions** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 7, 1022–1034, July 1953.

3066. Kheĭn, A. L., Irregular fl. .tion of fluids and gases in open stope wells not fully cleared from strata (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **91,** 3, 467–470, July 1953.

3067. Kheĭn, A. L., Irregular flow of fluids and gases to the hole of perforated wells during continuous filtration (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **91,** 5, 1039–1042, Aug. 1953.

Geophysics, Meteorology, Oceanography

(See also Revs. 2931, 2981)

3068. Railston, W., The temperature decay law of a naturally convected air stream, *Proc. phys. Soc. Lond. (B)* **67,** 409, part 1, 42–51, Jan. 1954.

A vertical convection current was produced in air by heating a small piece of wire-mesh gauze electrically. As the jet was carefully shielded from external drafts, the air flow was smooth throughout, as could be ascertained by means of schlieren observations. Thermistors were used to measure the temperature of the hot gauze, of various points in the air stream, and of the surroundings. Observations were made at three different rates of heat supply to the gauze. By making similar observations below the hot source, the rate of heat transfer by radiation and conduction could be estimated, and the observed temperature rise at points above the gauze could in this way be corrected for heat transfer other than convection. A graphical method was devised to correct the distances of the points where temperature observations were taken to what they would have been with a point source of heat.

The results are expressed in terms of the equations

$$\Delta\theta = 91.3Q^{0.675}z_0^{-1.52} \quad \text{and} \quad r = 0.40z_0^{0.85}$$

where $\Delta\theta$ is the mean value of the temperature rise in a circular area of radius r, a distance z_0 cm above a point source dissipating heat at the rate of Q watts in air under laboratory conditions; r is the radius of the cross section (measured to where the temperature rise is $^1/_{10}$ of the value at the axis) of the jet at height z_0. These results are in excellent agreement with the theoretical calculations of O. G. Sutton. W. Hitschfeld, Canada

3069. Faust, H., Why are there more low- than high-pressure areas? (in German), *Meteor. Rdsch.* **6,** 9/10, 182–185, Sept./Oct. 1953.

From spatially and temporally limited sample, author determines relative frequencies of low- and high-pressure areas at sea level and 500 millibars, over land and water. General preponderance of lows is attributed to the well-known characteristics of solutions of gradient-wind equation. Reviewer believes critical nature of statistical treatment is underemphasized; no reference is made to topological limitations on combinations of lows and highs on spherical earth. W. A. Baum, USA

3070. Vilkner, H., Vector treatment of winds (in German), *Z. meteor.* **7,** 7, 193–208, July 1953.

Author presents several methods for representing the time changes in wind direction and speed in a single curve. One is to plot wind direction vs. time with the thickness of the line representing wind speed. Another is to plot wind speed vs. time with shading the area under the curve with colors representing wind direction. Methods can be applied conveniently only to periods of less than a month or so. Another method consists in adding mean wind vector (head to tail) to represent longer periods up to a year. Paper is quite lengthy for subject treated.

W. P. Elliott, USA

3071. Hess, S. L., and Frank, R. M., A theory of the temporal and latitudinal distribution of temperature, *J. Meteor.* **10,** 2, 135–142, Apr. 1953.

A differential equation for atmospheric temperature is written in terms of conveniently simple expressions for insolation, radiative loss, and turbulent diffusion of heat. Solution in form of sums of Legendre polynomials gives temperature near earth's surface as function of latitude and time of year. Despite simplifications, agreement with observed mean monthly temperatures is generally good. Mathematical theory fails to explain lag of maximum and minimum after solstices. J. E. Miller, USA

3072. Lina, L. J., Measurements of pressure and temperature for appraisal of the temperature method of airspeed calibration in the lower stratosphere, *NACA TN* 3075, 12 pp., Mar. 1954.

An investigation was made to determine whether the temperature and pressure conditions in the lower stratosphere would meet the requirements of the temperature method for accurate calibration of air-speed installations. Measurements of temperature and pressure were made in flights of a swept-wing fighter airplane on four clear days in March and April, 1953, over land near Langley Field, Va. The results indicated that, although the temperature lapse rate was favorable to the method, large and erratic variations of temperature with time and distance precluded accurate calibration. Unfavorable atmospheric conditions had also been found previously in an investigation of the upper troposphere [AMR **6,** Rev. 2953]. From author's summary

3073. McNown, J. S., On the excitation of harbor waters due to action of the sea (in French), *Publ. sci. tech. Min. Air, Paris* no. 278, 45 pp., 1953.

In view of the complexity of the induced agitation of harbor waters by storms, the author believes that practical civil-engineering rules may be determined from the consideration of simple geometrical harbors. This is the complete report of theoretical study and model research which have been carried out on resonant and nonresonant induced motions in harbors.

By limiting himself to those cases where the mathematical calculations could be carried down to numerical applications, and where experimental tests could be made with the maximum amount of precision, the author has been able to establish equations which, with due care, might be applied to harbors of any shape. The main results have been published previously in *C. R. Acad. Sci., Paris* **232,** 2005–7, 1951; **233,** 21–3, 353–5. An interesting film has also been made by "Neyrpic," Grenoble, of some of these experiments, which are known as those of the "Crazy Harbor." A. G. Foster, England

Lubrication: Bearings; Wear

(See also Rev. 2866)

3074. Steller, A., Calculation of journal bearings with liquid lubricants (in German), *ZVDI* **96,** 4, 89–97, Feb. 1954.

With its formulas, diagrams, and tables, present paper yields all foundations necessary for a calculation of bearings.

First, journal bearings are considered. Author refers to results of a theoretical work of Fränkel which are represented in form of diagrams. The condition that the lowest thickness of the

lubricating film must be greater than the sum of the roughnesses of journal and bearing-bushing is the starting point for all calculations. If this condition is not guaranteed, no exclusive fluid friction exists. This latter condition is absolutely necessary for a regular running without failure. Further, an upper limit for the specific load is given by the elastic limit of the bearing materials, because at rest these must endure the load without plastic deformations. This leads to a condition for the upper limit of the relative clearance. Moreover, a proper selection of the lubricant must guarantee that the temperature of the bearing is not raised too high, since by diminution of the viscosity of the lubricant lowest thickness of the lubricating film decreases so that mixed friction begins. Therefore, at tolerable temperatures, the developed heat must be balanced by the heat which is led off. Either a lubricant with such viscosity-temperature dependence is chosen so that, at tolerable temperature, the heat developed by it is equal to the heat delivered to the surrounding atmosphere or, for a certain lubricant, it can be determined if and how much heat must be led off by an additional cooling. This is performed graphically.

Paper then deals with the calculation of thrust bearings with fixed pads as well as with tilting pads. Here author refers to his own theoretical paper of 1950. The above-mentioned viewpoints represent the starting points for the calculations of these thrust bearings, too.

At the end of the paper, the calculation is illustrated by several examples. U. Rost, Germany

3075. **Meldau, E., The distribution of load within deep-groove ball bearings** (in German), *Werkstatt u. Betrieb* **87**, 2, 71–77. Feb. 1954.

On the assumption that the center line of the shaft remains perpendicular to the planes containing the raceways, the effect of combined radial and thrust loading on the distribution of load between rolling elements is calculated. Assumed are horizontal and vertical deflections of the center of the bearing and ball loading is estimated from the corresponding ball deflections and displacements. First consideration is given to bearings with zero diametral clearance; then bearings having some initial play are dealt with. The results are presented in the form of curves in which the following quantities are shown plotted against the angle between resultant load on the bearing and the plane containing the raceways: (greatest-ball-loading)/(greatest-ball-loading-for-pure-radial-load); (average-ball-loading)/(average-ball-loading-for-pure-radial-load); and displacement of resultant thrust from bearing axis.

Each diagram consists of a family of curves, each representing a different value of a parameter which can be related to surface stress. It is therefore possible from the data provided to calculate the equivalent loading of any bearing under any condition of loading as related to a bearing without clearance subjected to purely radial load. Some caution is required in interpreting the data concerning bearings with a positive clearance when subjected to purely radial load. While it is not explicit in the paper, reviewer believes that the comparison is here between radial bearings with clearance and without clearance.

F. T. Barwell, Scotland

3076. **Raimondi, A. A., and Boyd, J., The influence of surface profile on the load capacity of thrust bearings with centrally pivoted pads,** ASME Ann. Meet., New York, Dec. 1953. Pap. 53—A-166, 18 pp.

Classical hydrodynamic theory of Kingsbury thrust bearings assumes the rubbing surface of the pads to be perfectly flat and predicts that the pads, to be able to assume a stable position, must be pivoted eccentrically. Practice, however, shows that centrally pivoted pads can yet be stable, even if there are no recognized factors (such as a sufficient degree of nonconstancy of viscosity along the oil film) that in theory would tend to make central pivoting workable.

Authors show theoretically and experimentally that convexity of the rubbing surfaces can well resolve the afore-mentioned paradox. Convexity can be obtained purposely by machining, or can come about inadvertently through the mechanical and thermal deflections that occur in service with pads that are flat in their unloaded state. There is an optimum crown, which amounts to one half the minimum film thickness and which, as regards load-supporting capacity, makes the convex, centrally pivoted pad almost equivalent to the flat pad with optimum eccentricity. In certain cases, convex pads are advantageous in that they start more easily than flat ones. H. Blok, Holland

3077. **Keller, W. M., Effect of viscosity on car journal oils on the running temperature and other characteristics of journal bearing performance,** ASME Ann. Meet., New York, Dec. 1953. Paper 53—A-111, 7 pp.

3078. **Haigold, F., Computation of bearing performance for reciprocating engines** (in German), *Maschinenbau-Technik* **2**, 11, 517–525, Nov. 1953.

3079. **Osterle, F., Charnes, A., and Saibel, E., On the solution of the Reynolds equation for slider-bearing lubrication—IV, Effect of temperature on the viscosity,** *Trans. ASME* **75**, 6, 1117–1121, Aug. 1953.

Problem of inclined-surface slider with film thickness varying exponentially is solved exactly, considering viscosity as a function of both pressure and temperature. Side leakage is not considered in this solution. Note starts from the Reynolds equation and an energy equation written for the case of adiabatic flow. Internal energy of lubricant is assumed to vary with temperature only. Once these laws of variation are known, mentioned equations reduce to simultaneous equations in pressure and temperature as the two unknowns. It is assumed that the logarithm of viscosity is proportional to the pressure and inversely proportional to the temperature, and the internal energy is linearly related to temperature.

The solution is illustrated by a numerical example and compared with result if the flow is isothermal (viscosity a function of pressure). Since pressure varies directly with viscosity and viscosity inversely with temperature, pressure distribution (and hence load-carrying capacity) is the maximum possible if flow is isothermal, and the minimum possible if flow is adiabatic; thus these assumptions lead to upper and lower bounds, respectively, on the load-carrying capacity.

An approximate solution to problem of bearing with side leakage is initiated by assuming lubricant temperature to vary linearly with x (direction of sliding) and to be independent of y (direction of width). This approximate solution is found to check very closely with exact solution for the infinite-slider case.

G. Vogelpohl, Germany

Marine Engineering Problems

(See also Rev. 2945)

3080. Marwood, W. J., and Johnson, A. J., Vibration tests on an up-river collier with special reference to the influence of depth of water, *N. E. Cst. Instn. Engrs. Ship. Trans.* **70,** part 3, 193–216, Jan. 1954.

Vibration measurements were made during a routine voyage of an up-river collier. The construction was all-riveted except for tank top.

The primary object of the measurements was to examine the influence of depth of water upon hull critical frequencies. It is shown that the influence of depth of water upon vertical vibration frequencies may be considered as negligible for h_w/d (depth of water to draught) ratios in excess of 5.0. For values of h_w/d less than 5.0, the frequencies decrease with increasing rapidity as h_w/d diminishes.

For transverse modes of vibration, the evidence obtained regarding the variation of frequency with depth of water was not so conclusive. It was revealed, however, that horizontal modes of vibration were not influenced to the same extent as the vertical modes.

The theoretical treatment of the problem is discussed briefly and attention is drawn in particular to the published works of Prohaska and Havelock. Comparisons are made where possible between the experimental results and those of these investigators. Some additional experimental data obtained on a model are given, which demonstrate the effect of a plane boundary upon flexural vibration in the vertical and horizontal planes and help to confirm certain conclusions arrived at by Havelock.

The hull vibration frequencies in deep water have been calculated by various methods and the results presented in tabular form. Strain measurements made during the loading of the vessel are described, the results being used as a guide in estimating the flexural rigidity of the ship girder.

From authors' summary

3081. Jasper, N. H., Preliminary report of strains and motions of the SS ESSO Asheville for the period 24 August 1952 through 31 July 1953, *David W. Taylor Mod. Basin Rep.* **875,** NS 731–037, 16 pp., Oct. 1953.

Stresses amidships as well as pitching and heaving accelerations were measured on a tanker during the vessel's normal commercial operations over the period August 1952 to July 1953. The data were obtained automatically, using a sampling procedure.

Analysis of the data indicates that the dynamic stress variations associated with the ship's motion in the waves will rarely exceed 10,000 psi peak to peak. Also, stress variations due to changes in temperature distribution, such as occur from night to day, are of the same order of magnitude as those due to changes in dead-load distribution. The maximum measured stress variation (free of stress concentration) due to change in temperature was about 10,900 psi. From author's summary

3082. Leide, N. G., The brittle-fracture problem from a shipbuilder's point of view, *Shipbuilder* **60,** 543, 577–581, Oct. 1953.

See AMR **7,** Rev. 367.

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INDEX OF AUTHORS REFERRED TO IN THIS ISSUE (Continued)

Krishnan, R. M. 2884
Krzywoblocki, M. Z. V. 2925
Kuenzi, E. W. 2804
Kugler, A. N. 2813
Kuhns, P. W. 2911
Lambert, R. F. 3034
Landahl, M. 2936
Landecker, K. 2762
Lane, I. R. 2816
Langhaar, H. L. 2785
Larrabee, E. 2940
Lee, R. 3043
Leeser, D. O. 2784
Leide, N. G. 3082
Lesher, E. J. 2932
Leth, C. F. A. 2759
Levesque, G. N. 2895
Levin, L. R. 2799
Li, C. H. 2872
Li, C. Y. 3061
Lina, L. J. 3072
Livesley, R. K. 2828, 2829
Louwerse, P. 2977
Lucas, D. H. 2778
Lucas, R. 3032
Lunbeck, R. J. 2977
Mailander, R. 2858
Majors, H., Jr. 2887, 2888
Mandel, J. 3056
Mansfield, E. H. 2837
March, H. W. 2804
Marini, M. 2923
Markgraf, H.-G. 2983
Maron, S. H. 2841
Martin, A. 2782
Martin, B. W. 2998
Martin, M. H. 2909
Martinek, J. 2937
Marwood, W. J. 3080
Masi, J. F. 2974
Masur, E. F. 2756
Matulaitis, V. E. 2891
Mayer, E. H. 2903
McNown, J. S. 3073
McShane, E. J. 3046
Medici, M. 2952
Meksyn, D. 2907
Meldau, E. 3075
Merbt, H. 2936
Meyer, E. 3040
Meyerhof, G. G. 2875
Michael, W. H., Jr. 2919
Michels, A. 2977, 2978
Mickevicz, E. J. 2864
Mironoff, N. 2844
Mischke, C. R. 2994
Mitchner, M. 2913
Mohaupt, A. A. 2876
Monerieff, D. S. 2823
Montens 2962
Moore, F. K. 2917
Morris, H. N. 2899
Mortlock, A. J. 2987
Muhs, H. 3060
Mustard, J. N. 2873
Naghdi, P. M. 2789
Nathorst, H. 2870
Neuber, H. 2801
Newby, M. P. 3014
Nijhawan, B. R. 2884
Nikuradse, A. 2983
Nomoto, O. 3031
Norr, A. 2797
Norrish, R. G. W. 3019
Novikov, V. I. 2877
Ohlig, R. 2825
Öhman, L. 2849, 2905
O'Shaughnessy, M. T. 2881
Osterle, F. 3079
Oxford, C. J., Jr. 2894
Pancaldi, G. 3012
Parker, E. R. 2872
Parker, R. J. 2885
Partlow, J. G. 2941
Payne, P. R. 2933
Peacock, D. W. 2970
Pearmain, G. J. 2817
Pélegrin, M. J. 2747
Penzien, J. 2753
Peres, N. J. C. 2863
Persh, J. 2954
Peter, S. 2982
Pettersson, O. 2791, 2792
Pickett, G. 2794
Pirson, E. 2822
Pittoni, M. 2969
Pletta, D. H. 2742
Pollock, W. A. 2943
Popoff, K. 2971, 2972
Powers, M. D. 2973
Powley, H. S. 3047
Pravoverov, K. N. 3023
Preston, J. H. 2928
Preston, J. M. 2879
Price, C. F. 3020
Pucher, A. 2820
Railston, W. 3068
Raimondi, A. A. 3076
Rausch, E. 2835
Reno, F. V. 3046
Reynolds, C. E. 3054
Richard, K. 2860
Ritchings, F. A. 2867, 2944
Roark, R. J. 2764
Robinson, W. P. 2956
Robitzsch, M. 2981
Roe, G. M. 2973
Rogers, G. L. 2824
Rosecrans, R. 2787
Rowling, H. 3025
Russell, J. G. 2774
Ryder, F. L. 2783
Saha, M. R. 2833
Saibel, E. 3079
Saltzberg, B. 2737
Sattler, K. 2807, 2850
Schaaf, S. A. 2979
Schlechte, F. R. 2787
Scholz, H. 2960
Schuh, H. 2914
Schwalbe, W. L. 2790
Scurlock, A. C. 3017
Sellerio, A. 2959
Sengupta, H. M. 2795
Shank, M. E. 2843
Shepheard, R. B. 2811
Sherlock, R. H. 2932
Shorin, S. N. 3023
Siebel, E. 2882
Siekmann, H. J. 2896
Silva, F. P. 3063
Sims, L. G. A. 2991
Simultaneous linear equations 2736
Sjöström, S. 2775
Skempton, W. 3050
Skudrzyk, E. 3040
Sodha, M. S. 2989
Soete, W. 2854
Space heating 3005
Spalding, D. B. 3008, 3021
Stableford, W. H. 2781
Stebel, O. J. 2960
Steinhardt, O. 2830
Steller, A. 3074
Sternberg, R. L. 2749
Stevens, G. L. 2922
Stewart, R. C. 3062
Stiehler, R. D. 2990
Stivers, L. S., Jr. 2921
Stoke, R. C. 2891
Stoker, J. J. 2763
Stott, V. H. 2846
Streck, O. 2898
Strehlow, R. A. 2980
Stüssi, F. 2755, 2808
Sykes, A. O. 2758
Symonds, P. S. 2759
Syutkin, N. F. 2771
Szablewski, W. 2901
Széchy, K. 2839
Talbot, L. 2900
Thickstun, W. R. 2909
Thorsen, N. 2826
Thring, M. W. 3014
Thum, A. 2860
Tifford, A. N. 3004
Torda, T. P. 2912
Towler, F. H. 2890
Towler, J. M. 2890
Travers, S. 2930
Troutman, J. L. 2799
Tyabin, N. V. 2842
van Den Bergen, A. C. 2906
van der Willigen, P. C. 2815
Van Seventer, W. 2978
Varshni, Y. P. 2989
Vernotte, P. 2999
Verschaffelt, J. E. 2985, 2986
Vilkner, H. 3070
Vodar, B. 2975
von Gorup, G. 2740
Waidelich, A. T. 2773
Waitkus, J. 3010
Walker, V. 2950
Walters, A. G. 3044
Wardlaw, R. L. 2997
Warren, C. H. E. 2927
Washa, G. W. 2852
Washburn, J. 2872
Wassenaar, T. 2977, 2978
Weiss, S. J. 3062
Welsh, A. F. 2886
Weltmann, Ruth N. 2911
Werren, F. 2876
Westervelt, P. J. 3033
Weston, D. E. 3035, 3036
Wilder, J. G., Jr. 2908
Wilhoit, J. C., Jr. 2767
Williams, M. L. 2931
Wilson, T. S. 2757
Wisniowski, H. U. 3022
Wittenberg, H. 2942
Woinowsky-Krieger, S. 2796
Wolkers, G. J. 2977
Woodcock, A. H. 3009
Woodling, C. H. 2918
Yampolsky, J. 3020
Yassin, A. M. 2902
Yates, J. G. 2778
Yeh, G. C. K. 2937
Yeh, V. C. M. 2748
Yost, J. H. 2956
Young, R. B. 2873
Zadumkin, S. N. 2988
Zaremba, S. K. 2738
Zatt, J. A. 2916
Zatzkis, H. 3028

INDEX OF AUTHORS REFERRED TO IN THIS ISSUE

(NUMBERS USED ARE SERIAL NUMBERS OF REVIEWS)

Aitchison, G. D. 2996
Alford, J. S. 2946
Alfrey, T., Jr. 2881
Allen, T. O. 3049
Alsmeyer, W. C. 2834
Anderson, A. W. 2838
Anonymous 2967
Arons, A. B. 3009
Atterbury, J. H., Jr. 3049
Axelson, J. A. 2922
Backer, G. H. 2955
Bailey, B. M. 2954
Barkeling, E. 2819
Barker, R. S. 2777
Barrett, J. C. 2816
Bartenev, G. M. 2877
Beatrix, C. 2938, 2939
Beaufoy, L. A. 2831
Beckmann, G. 2779
Bell, S. 2979
Benham, P. P. 2780
Bennek, H. 2858
Benser, W. A. 2949
Bereis, R. 2744
Berger, E. R. 2805
Bergström, S. G. 2874
Bernard, J.-J. 2910
Berry, J. G. 2789
Betteridge, W. 2871
Beutel, H. 2897
Bieberbach, L. 2735
Bijlaard, P. P. 2800
Birmann, R. 2948
Birnbaum, W. 2935
Bishop, R. E. D. 2754
Blackwell, J. H. 2992
Blanch, Gertrude 2739
Blanchard, D. C. 3009
Boerdijk, A. H. 2750
Boothe, W. 2788
Boreli, M. 3064
Bornscheuer, F. W. 2803
Boston, O. W. 2896
Bottger 2976
Bowden, A. T. 3025
Bowman, C. E. 2856
Boyd, J. 3076
Boyum, W. B. 2941
Brachet, R. 2776
Braddon, G. 3010
Braught, G. 3007
Bright, N. F. H. 2880
Broer, L. J. F. 2906
Brown, N. 2853
Bruce, V. G. 2806
Bückle, H. 2861
Burgan, E. T. 2838
Burgers, J. M. 2913
Burk, S. M., Jr. 2957
Burrell, G. 2953
Burtow, A. J. 2892
Burzyński, W. 2770
Butler, F. G. 2953
Cabannes, H. 2904
Campbell, I. D. 3036
Carhart, R. R. 3037
Carpenter, P. J. 2929
Carrier, G. F. 2915
Carson, T. 2880
Carver, D. R. 2785
Casci, C. 2947
Catsiff, E. 2881
Cavallaro, L. 3012
Cavicchi, R. H. 2951
Chantal, R. 2741
Charlton, T. M. 2829
Charnes, A. 3079
Chase, H. J. 2945
Chetayev, D. N. 3039
Chu, S. T. 3004
Clabaugh, W. J. 3000
Clark, J. F. 2879
Cohen, H. 2998
Cohn, G. I. 2737
Coles, W. D. 2993
Conn, W. M. 3006, 3007
Cook, M. 2885
Copson, E. T. 3026, 3027
Cowan, H. J. 2821
Cox, H. L. 2765
Crocker, S. 2867, 2944
Cude, A. L. 3018
Czyzewski, H. 2866
da Cunha Amaral, A. M. 2832
Dahl, N. C. 2786
Dapoigny, J. 2975
Das, S. C. 2793
Daughaday, H. 2934
de Baare, J. 2878
Decker, G. E. 2990
Defize, F. L. 2815
Delavault, H. 3003
de Leiris, H. 2966
del Salvatore, A. 2836
Demorest, D. J. 2784
Dennis, N. G. 2752
de Saint-Marc, G. S. 3064
de Vries, G. 3057
Dodson, C. R. 2903
Dolan, T. J. 2856
Dow, N. F. 2799
Duff, G. M. 2880
Draper, P. 3025
Dunham, J. W. 3051
Duncan, W. J. 2768
Eggwertz, S. 2797
Ehricke, K. A. 2746
English, R. E. 2951
Epstein, L. F. 2973
Epstein, P. S. 3037
Esch, R. 3013
Esclangon, E. 3045
Esmiol, E. E. 3058
Fabri, J. 3015
Farber, E. A. 2994
Faulders, C. R. 2958
Faust, H. 3069
Ferguson, C. K. 3048
Ferguson, R. L. 2845
Ferguson, R. W. 2941
Fischer, W. A. 2847
Fluck, P. G. 2852
Focken, C. M. 2734
Folliot, A. 3024
Ford, H. 2840
Foust, A. S. 2772
Fowler, H. S. 2950
Frank, R. M. 3071
Frey, K. 2818
Fridovich, B. 2929
Fröhlich, O. K. 3055
Gale, A. G. 2945
Gates, O. B., Jr. 2918
Geronimus, Ya. L. 2743
Gifford, F. W. 2859
Gilbert, W. W. 2896
Girkmann, K. 2827
Goldhammer, B. F. 2802
Goodier, J. N. 2809
Goodwill, D. 2903
Grandvoinnet, J. 3052
Gray, R. T. 2788
Greenberg, S. A. 2869
Grégoire, M. 2968
Gross, R. A. 3013
Grossetti, E. 3032
Grover, J. H. 3017
Grover, LaM. 2814
Gruner, E. 3059
Gruner, G. 3059
Haigold, F. 3078
Halliday, W. M. 2883
Hansen, M. 2960
Hansen, R. J. 2753
Harding, H. V. 2891
Hardrath, H. F. 2849
Hardwick, W. R. 2893
Hartnett, J. P. 3000
Hasegawa, M. 2924
Head, A. K. 2857
Head, V. P. 2961
Healy, F. M. 2957
Heebink, B. G. 2876
Heller, G. S. 3030
Hemeon, J. R. 3011
Hess, S. L. 3071
Hibbert, Celesta J. 2973
Hindersinn, K. 2908
Hoadley, A. 2769
Hodge, P. G., Jr. 2848
Hodgkinson, T. G. 3041
Hoff, N. J. 2806
Hollander, L. 2751
Hormann, E. 2812
Horvay, G. 2788
Hottenrott, E. 2855
Houdremont, E. 2858
Huber, R. W. 2816
Huff, H. A., Jr. 2813
Huggins, M. W. 2865
Hughes, J. E. 2810
Huppert, M. C. 2949
Indelli, A. 3012
Ireland, M. L., Jr. 2944
Iwanami, S. 2964, 2965
Janes, W. C. 2794
Janssen, J. H. 3042
Jasper, N. H. 3081
Jessop, H. T. 2781
Johnson, A. J. 3080
Johnson, H. A. 3000
Johnson, S. J. 3053
Johnston, D. L. 2778
Johnston, G. S. 2800
Jordan, G. V., Jr. 2984
Jorissen, A. L. 2963
Jung, H. 2766
Junger, M. C. 2761
Kane, T. R. 2760
Kapadnis, D. G. 3062
Karlovitz, B. 3016
Kaufman, H. 2749
Kaye, J. 3001
Kazakevich, N. L. 2745
Keller, W. M. 3077
Kelley, J. L. 3046
Kelly, H. R. 2920
Kerekes, F. 2834
Kestin, J. 2738
Keune, F. 2926
Khanna, M. N. 2884
Kharanen, V. Y. 3038
Kheĭn, A. L. 3066, 3067
Khudyakov, G. N. 3065
Kieffer, J. 2975
Kientzler, C. F. 3039
Kienzle, O. 2889
Kishimoto, T. 3031
Kline, J. 2934
Klotz, J. A. 3048
Knittel, G. 2851
Knox, J. H. 3019
Kohaut, A. 2862
Kolesnikov, A. G. 2995
Kornhauser, E. T. 3029
Koster, W. 2868
Kravtchenko, J. 3064
Krettner, J. 2798
Krieger, I. M. 2841

(Continued on inside back cover)